ERDC/CHL TR-10-11

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Seabrook and Borgne Alignment Construction Sequence Hydrodynamic Study

Jennifer N. Tate and Cassandra G. Ross

December 2010

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **DEC 2010**	2. REPORT TYPE	3. DATES COVERED **00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE **Seabrook And Borgne Alignment Construction Sequence Hydrodynamic Study**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Engineer Research and Development Center,Coastal and Hydraulics Laboratory,3909 Halls Ferry Road,Vicksburg,MS,39180-6199**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U.S. Army Corps of Engineers (USACE) Hurricane Protection Office (HPO) is authorized to provide New Orleans, Louisiana, with a risk reduction system for the one percent exceedance flood (HSDRRS). The purpose and need for the proposed action is to provide, in a timely manner, the 100-year level of risk reduction from flood damage to the areas surrounding the IHNC due to flooding from hurricanes and other severe storm events. This risk reduction is being accomplished through the construction of a comprehensive system of levees, gates, and drainage structures. Several planned structures (to be located along the levee system) allow for continued navigation in the Inner Harbor Navigation Canal (IHNC), Bayou Bienvenue, and the Gulf Intracoastal Waterway (GIWW). The IHNC Seabrook, Bayou Bienvenue, and GIWW gate structures are designed to remain open during normal tidal conditions with the ability to close during surge events. Numerical model studies were performed by the USACE Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) to assess the impacts of these navigation structures on hydrodynamics and larval transport. HPO requested that ERDC also perform a numerical modeling study for the purpose of analyzing the temporary construction impacts of proposed HSDRRS measures to be placed in the GIWW and the Mississippi River Gulf Outlet (MRGO). The work presented in this report documents hydrodynamic modeling and analysis of two construction sequence plans which will occur during the construction of the Borgne alignment and Seabrook structures included in the HSDRRS. This report specifically focuses on the construction sequence plans during which the Bayou Bienvenue structure and GIWW sector gate are being built as well as the construction of the Seabrook structure. The February 2010 plan includes cofferdams on the Bayou Bienvenue and at the GIWW sector gate in addition to closing the MRGO at La Loutre and south of Bayou Bienvenue. The March 2010 plan adds a cofferdam at Seabrook. Water surface elevation, velocity magnitude and direction, and percent less than analyses were performed at several locations within the model domain, focusing on the areas likely to be affected by the plan changes.

15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**80**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ERDC/CHL TR-10-11
December 2010

Seabrook and Borgne Alignment Construction Sequence Hydrodynamic Study

Jennifer N. Tate and Cassandra G. Ross

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers
New Orleans District, Hurricane Protection Office
7400 Leake Ave., Rm 184
New Orleans, LA 70118

Abstract: The U.S. Army Corps of Engineers (USACE) Hurricane Protection Office (HPO) is authorized to provide New Orleans, Louisiana, with a risk reduction system for the one percent exceedance flood (HSDRRS). The purpose and need for the proposed action is to provide, in a timely manner, the 100-year level of risk reduction from flood damage to the areas surrounding the IHNC due to flooding from hurricanes and other severe storm events. This risk reduction is being accomplished through the construction of a comprehensive system of levees, gates, and drainage structures. Several planned structures (to be located along the levee system) allow for continued navigation in the Inner Harbor Navigation Canal (IHNC), Bayou Bienvenue, and the Gulf Intracoastal Waterway (GIWW). The IHNC Seabrook, Bayou Bienvenue, and GIWW gate structures are designed to remain open during normal tidal conditions with the ability to close during surge events. Numerical model studies were performed by the USACE Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) to assess the impacts of these navigation structures on hydrodynamics and larval transport. HPO requested that ERDC also perform a numerical modeling study for the purpose of analyzing the temporary construction impacts of proposed HSDRRS measures to be placed in the GIWW and the Mississippi River Gulf Outlet (MRGO). The work presented in this report documents hydrodynamic modeling and analysis of two construction sequence plans which will occur during the construction of the Borgne alignment and Seabrook structures included in the HSDRRS. This report specifically focuses on the construction sequence plans during which the Bayou Bienvenue structure and GIWW sector gate are being built as well as the construction of the Seabrook structure. The February 2010 plan includes cofferdams on the Bayou Bienvenue and at the GIWW sector gate in addition to closing the MRGO at La Loutre and south of Bayou Bienvenue. The March 2010 plan adds a cofferdam at Seabrook. Water surface elevation, velocity magnitude and direction, and percent less than analyses were performed at several locations within the model domain, focusing on the areas likely to be affected by the plan changes.

Contents

Figures and Tables iv

Preface vii

Unit Conversion Factors viii

1 Introduction 1

Background 1

Technical Approach 3

2 Model Development 4

Hydrodynamic Numerical Model Code 4

Mesh Development 5

Boundary Conditions 5

Model Validation 7

3 Construction Sequence Plans 8

Model Scenarios 8

4 Hydrodynamic Results 15

Velocity Magnitudes 15

Water Surface Analysis 28

Circulation Changes 47

5 Conclusions 49

References 51

Appendix A: Half Cofferdam at Seabrook 52

Report Documentation Page

Figures and Tables

Figures

Figure 1-1. Vicinity map. 2

Figure 1-2. Project area map. 3

Figure 2-1. Model domain and bathymetry. 6

Figure 2-2. Location of river inflows. 6

Figure 3-1. Base configuration: no closures, no structures. 8

Figure 3-2. Plan 1 configuration: close the MRGO at La Loutre. 9

Figure 3-3. Plan 2 configuration: includes Plan 1 and the Borgne alignment. 10

Figure 3-4. February 2010 configuration: close the MRGO at La Loutre, close the MRGO south of Bayou Bienvenue, cofferdam at the Bayou Bienvenue gate, cofferdam at the sector gate on GIWW, and open the 150 ft X 16 ft barge gate on GIWW. 11

Figure 3-5. March 2010 configuration: includes February 2010 configuration with a cofferdam at the Seabrook structure as well. 11

Figure 3-6. Tide signal for the September analysis period. 12

Figure 3-7. Tide signal for the March analysis period. 13

Figure 3-8. Wind signal for the September analysis period. 13

Figure 3-9. Wind signal for the March analysis period. 14

Figure 4-1. Hydrodynamic analysis locations – Seabrook. 15

Figure 4-2. Hydrodynamic analysis locations – Bayou Bienvenue Structure, GIWW Sector Gate, and GIWW Barge Gate. 16

Figure 4-3. Hydrodynamic analysis locations – Chef Menteur and Rigolets. 16

Figure 4-4. Velocity average for September (positive). 17

Figure 4-5. Velocity average for September (negative). 17

Figure 4-6. Velocity maximum for September (positive). 18

Figure 4-7. Velocity minimum for September (negative). 18

Figure 4-8. Velocity average for March (positive). 19

Figure 4-9. Velocity average for March (negative). 19

Figure 4-10. Velocity maximum for March (positive). 20

Figure 4-11. Velocity minimum for March (negative). 20

Figure 4-12. Percent less than of velocity magnitude analysis locations. 22

Figure 4-13. GIWW Barge Gate percent less than plot for September. 22

Figure 4-14. Seabrook percent less than plot for September. 23

Figure 4-15. Chef Menteur percent less than plot for September. 23

Figure 4-16. Rigolets percent less than plot for September. 24

Figure 4-17. Lake Pontchartrain percent less than plot for September. 24

Figure 4-18. Lake Borgne percent less than plot for September. 25

Figure 4-19. GIWW Barge Gate percent less than plot for March. 25

Figure 4-20. Seabrook percent less than plot for March. 26
Figure 4-21. Chef Menteur percent less than plot for March. 26
Figure 4-22. Rigolets percent less than plot for March. 27
Figure 4-23. Lake Pontchartrain percent less than plot for March. 27
Figure 4-24. Lake Borgne percent less than plot for March. 28
Figure 4-25. Location map for water surface analysis. 29
Figure 4-26. Inset for water surface analysis location map. 29
Figure 4-27. Water surface elevation north of MRGO closure at La Loutre. 30
Figure 4-28. Water surface elevation south of MRGO closure at La Loutre. 30
Figure 4-29. Water surface elevation north of MRGO closure at Bayou Bienvenue 31
Figure 4-30. Water surface elevation south of MRGO closure at Bayou Bienvenue. 31
Figure 4-31. Water surface elevation west of Bayou Bienvenue structure. 32
Figure 4-32. Water surface elevation east of Bayou Bienvenue structure. 32
Figure 4-33. Water surface elevation west of GIWW structures. 33
Figure 4-34. Water surface elevation east of GIWW structures 33
Figure 4-35. Water surface elevation north of Seabrook structure. 34
Figure 4-36. Water surface elevation south of Seabrook structure. 34
Figure 4-37. Water surface elevation in GIWW at IHNC. 35
Figure 4-38. Water surface elevation in Chef Menteur 35
Figure 4-39. Water surface elevation north in Rigolets. 36
Figure 4-40. Water surface elevation at Lake Borgne perimeter. 36
Figure 4-41. Water surface elevation at Lake Borgne center. 37
Figure 4-42. Water surface elevation at Lake Pontchartrain. 37
Figure 4-43. Water surface elevation north of MRGO closure at La Loutre. 38
Figure 4-44. Water surface elevation south of MRGO closure at La Loutre. 38
Figure 4-45. Water surface elevation north of MRGO closure at Bayou Bienvenue. 39
Figure 4-46. Water surface elevation south of MRGO closure at Bayou Bienvenue. 39
Figure 4-47. Water surface elevation west of Bayou Bienvenue structure 40
Figure 4-48. Water surface elevation east of Bayou Bienvenue structure. 40
Figure 4-49. Water surface elevation west of GIWW structures. 41
Figure 4-50. Water surface elevation east of GIWW structures. 41
Figure 4-51. Water surface elevation north of Seabrook structure. 42
Figure 4-52. Water surface elevation south of MRGO Seabrook structure. 42
Figure 4-53. Water surface elevation in GIWW at IHNC. 43
Figure 4-54. Water surface elevation in Chef Menteur. 43
Figure 4-55. Water surface elevation in Rigolets. 44
Figure 4-56. Water surface elevation at Lake Borgne perimeter. 44
Figure 4-57. Water surface elevation at Lake Borgne center 45
Figure 4-58. Water surface elevation in Lake Pontchartrain. 45
Figure 4-59. February 2010 plan circulation. 48

Figure 4-60. March 2010 plan circulation. 48
Figure A1. Seabrook Half cofferdam configuration. 53
Figure A2. Hydrodynamic analysis location – Seabrook. 54
Figure A3. Velocity average for September (positive). 54
Figure A4. Velocity average for September (negative). 55
Figure A5. Velocity maximum for September (positive). 55
Figure A6. Velocity minimum for September (negative). 56
Figure A7. Velocity average for March (positive). 56
Figure A8. Velocity average for March (negative). 57
Figure A9. Velocity maximum for March (positive). 57
Figure A10. Velocity minimum for March (negative). 58
Figure A11. GIWW Barge Gate percent less than plot for September. 59
Figure A12. Seabrook percent less than plot for September. 60
Figure A13. Chef Menteur percent less than plot for September. 60
Figure A14. Rigolets percent less than plot for September. 61
Figure A15. GIWW Barge Gate percent less than plot for March. 61
Figure A16. Seabrook percent less than plot for March. 62
Figure A17. Chef Menteur percent less than plot for March. 62
Figure A18. Rigolets percent less than plot for March. 63
Figure A19. Water surface elevation west of GIWW structures. 64
Figure A20. Water surface elevation east of GIWW structures. 64
Figure A21. Water surface elevation north of Seabrook structure 65
Figure A22. Water surface elevation south of Seabrook structure 65
Figure A23. Water surface elevation in GIWW at IHNC. 66
Figure A24. Water surface elevation west of GIWW structures. 66
Figure A25. Water surface elevation east of GIWW structures. 67
Figure A26. Water surface elevation north of Seabrook structure. 67
Figure A27. Water surface elevation south of MRGO Seabrook structure. 68
Figure A28. Water surface elevation in GIWW at IHNC. 68

Tables

Table 1. Average velocity values at the GIWW and Seabrook structures for the base and each construction sequence plan during both analysis periods 49
Table A1. Average velocity values at the GIWW and Seabrook structures for the base and each construction sequence plan and the half Seabrook cofferdam during both analysis periods 58

Preface

The model investigation presented in this report was authorized and funded by the U.S. Army Corps of Engineers Hurricane Protection Office (HPO), New Orleans, LA, in an effort to support the navigation impacts analysis modeling of the proposed construction sequence for hurricane protection structures along the Gulf Intracoastal Waterway and Inner Harbor Navigation Canal. This work was performed in conjunction with the environmental impacts analysis modeling effort which will be documented in Individual Environmental Report #11 Tier 2 Pontchartrain for the improved protection of the Inner Harbor Navigation Canal. This work was conducted by Jennifer Tate and Cassandra Ross.

This work was conducted at the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center (ERDC) during the period of June 2009 to July 2009 under the direction of Dr. William D. Martin, Director of the CHL; Bruce Ebersole, Chief of the Flood and Storm Protection Division, CHL; Dr. Robert McAdory, Chief of the Estuarine Engineering Branch, CHL.

COL Gary E. Johnston was Commander and Executive Director.
Dr. Jeffery P. Holland was Director of ERDC.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
fathoms	1.8288	meters
feet	0.3048	meters
foot-pounds force	1.355818	joules
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
knots	0.5144444	meters per second
microns	1.0 E-06	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
slugs	14.59390	kilograms
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

1 Introduction

Background

The U.S. Army Corps of Engineers (USACE) Hurricane Protection Office (HPO) is authorized to provide New Orleans, Louisiana, with a risk reduction system for the one percent exceedance flood, Hurricane and Storm Damage Risk Reduction System (HSDRRS). The purpose and need for the proposed action is to provide, in a timely manner, the 100-year level of risk reduction from flood damage to the areas surrounding the Inner Harbor Navigation Canal (IHNC) due to flooding from hurricanes and other severe storm events. The term "100-year level of risk reduction," as it is used throughout this document, refers to a level of risk reduction that reduces the risk of storm surge and wave-driven flooding in the New Orleans Metropolitan Area to a one percent chance in any given year. The proposed action resulted from a defined need to reduce flood risk and storm damage to residences, businesses, and other infrastructure from hurricanes (100-year storm events), and other high water events. The completed HSDRRS would lower the risk of harm to citizens and damage to infrastructure during a storm event.

This risk reduction is being accomplished through the construction of a comprehensive system of levees, gates, and drainage structures. Several planned structures (to be located along the levee system) allow for continued navigation in the IHNC, Bayou Bienvenue, and the Gulf Intracoastal Waterway (GIWW). The IHNC Seabrook, Bayou Bienvenue, and GIWW gate structures are designed to remain open during normal tidal conditions with the ability to close during surge events, however, navigation results may require a change in the operation procedures. Numerical model studies were performed by the USACE Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) to assess the impacts of these navigation structures on hydrodynamics and larval transport and were reported in Tate et al. 2010.

HPO requested that ERDC also perform a numerical modeling study for the purpose of analyzing the temporary construction impacts of proposed HSDRRS measures to be placed in the GIWW and the Mississippi River Gulf Outlet (MRGO).

Figure 1-1 shows the project vicinity. Figure 1-2 shows a more detailed project area.

The MRGO Canal is a 66-mile-long deepwater channel that extends northwest from deep water in the Gulf of Mexico to New Orleans, LA. The MRGO merges with the GIWW and continues five miles further to the west where it joins the IHNC. The IHNC continues approximately another three miles north from its intersection with the GIWW to connect with Lake Pontchartrain at Seabrook. To the East of the connection of the GIWW with the MRGO, the GIWW extends northeast approximately six miles to its first connection with Lake Borgne and 20 miles to its connection to the Rigolets, located to the northeast of Chef Menteur beyond the extent of Figure 1-2.

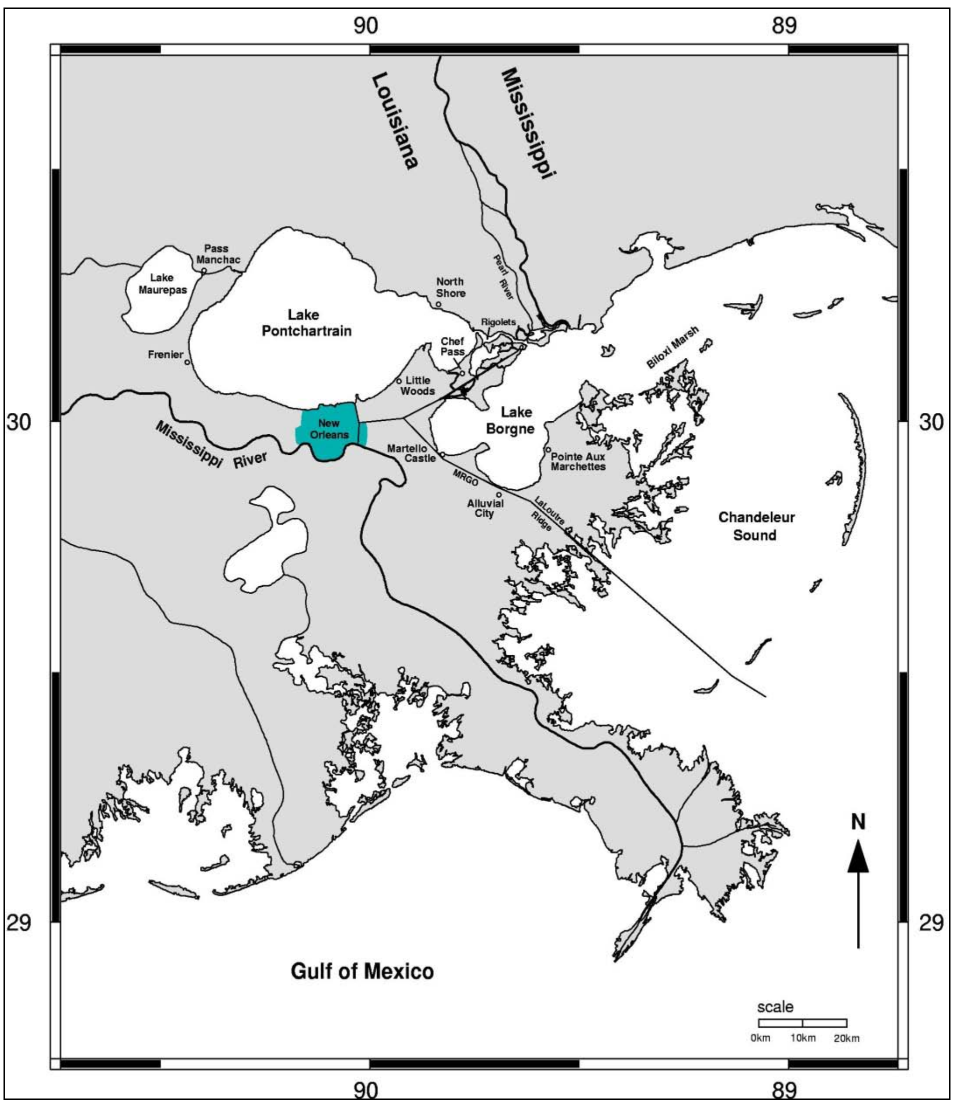


Figure 1-1. Vicinity map.

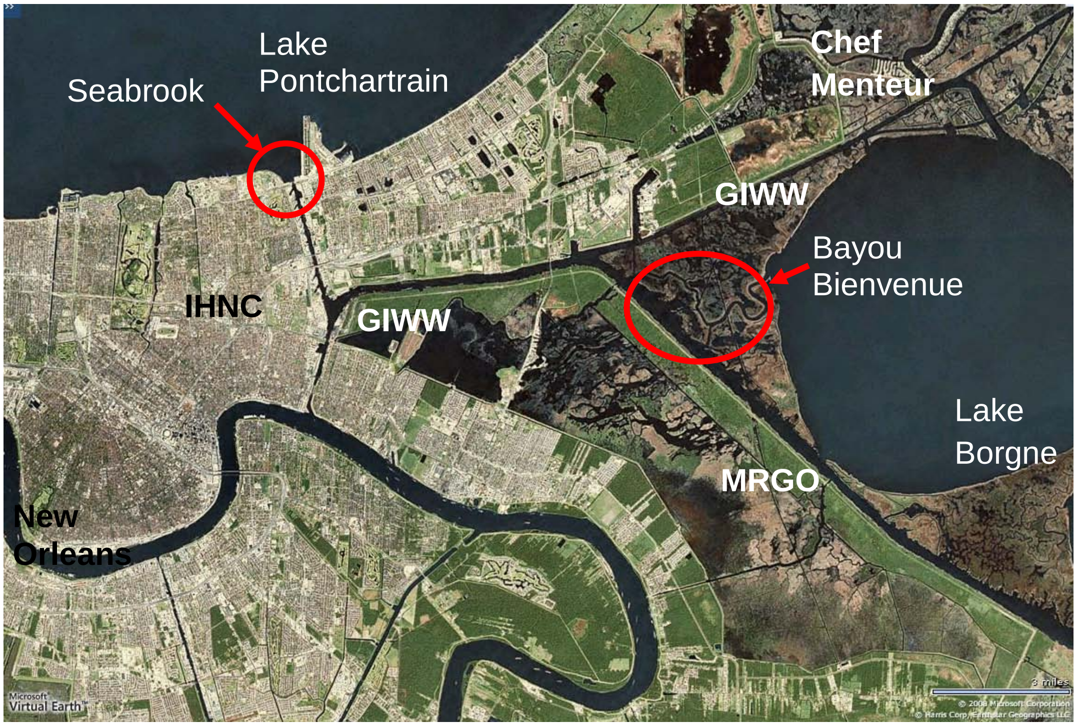


Figure 1-2. Project area map.

Technical Approach

This study involves numerical hydrodynamic modeling using the shallow water module of the Adaptive Hydraulics (AdH) code in two-dimensions. The modeling effort presented in this document is continued from the effort performed in Tate et al. 2010. Details of the model development, mesh characteristics, boundary condition generation, and model validation are found in Tate et al. 2010. A discussion of the AdH code is also included in Tate et al. 2010. Since this specific work concerns the construction sequence of the protection measures, a structure is considered to be either open or closed for the entire time of a simulation. The results of these simulations will be compared to results for a plan in which no changes are made to the system, a plan in which the MRGO is cut off at La Loutre, and a plan in which the MRGO is cut off at La Loutre and the Borgne alignment is in place. In Tate et al. 2010, these plans are, respectively, Base, Plan 1, and Plan 2. Further details of the conditions used for simulation and comparison will be provided in Chapter 3.

The time periods for simulation and analysis are the same as those presented in Tate et al. 2010. Two different four-week periods are simulated as specified by HPO. The periods included for these simulations are August 15 – September 15, 2007 and March 1-31, 2008.

2 Model Development

Hydrodynamic Numerical Model Code

A hydrodynamic numerical model is composed of: a numerical model code; a computational mesh that is a digital representation of the system under study, incorporating important features, such as bathymetry, etc., of the system adequately to answer questions posed; data suitable for developing the mesh, boundary condition files incorporating the system forcings and data for use in validating the model's calculated results of, for example, water level, velocity, etc.; and, finally, a demonstration that the model represents the system adequately to answer the questions for which the model was developed. This digital, validated system of files and codes is, then, a model representation of the system. The hydrodynamic code used in this study, AdH, is a finite element code that can simulate three-dimensional groundwater, three-dimensional Navier-Stokes, and two- and three-dimensional shallow water equations. This study utilizes the two-dimensional (2D) shallow water equations of AdH. The 2D shallow water module of AdH solves for depth and depth averaged velocity throughout the model domain. In this case, density effects due to salinity or other factors are ignored and therefore their effects on the flow are not included in these simulations and results. In this application, the model is simulated on high performance computing machines in order to obtain results as quickly as possible. Further details on the AdH model and its equations can be found at https://adh.usace.army.mil or in Appendix B of Tate et al. 2010.

The AdH code can be used in a serial or multiprocessor mode on personal computers, UNIX, Silicon Graphics, and CRAY operating systems. The uniqueness of AdH is its ability to dynamically refine the domain mesh in areas where more resolution is needed at certain times due to changes in the flow conditions. AdH can simulate the transport of conservative constituents, such as dye clouds or salinity, as well as sediment transport that is coupled to bed and hydrodynamic changes. The ability of AdH to allow the domain to wet and dry within the marsh areas as the tide changes is suitable for the shallow marsh environment present in a few locations included in the model domain. AdH is a research and development product of the USACE System Wide Water Resources Program (SWWRP). AdH has been used to model sediment transport in

sections of the Mississippi River, tidal conditions in southern California, and vessel traffic in the Houston Ship Channel, among others.

Mesh Development

The computational model domain is given in Figure 2-1. This is the same model domain as in previous studies of this area as described in McAnally et al. 1997 and Tate et al. 2002. This mesh has since been modified to include more recent bathymetry and additional marsh storage and flow pathways for the navigation study of the Borgne alignment. The domain extends east of the Chandeleur Islands in the Gulf of Mexico, follows the coastline of Mississippi and Louisiana on the north, follows the MRGO on the south, and includes Lake Pontchartrain and Lake Maurepas. The actual mesh was taken from that used in the IHNC navigation study (Martin et al. 2010) and modified to fit the AdH format of linear, triangular elements. Bathymetry data were collected by ERDC-CHL in the IHNC, GIWW, Bayou Bienvenue and northern MRGO in November 2008. These data were incorporated into the mesh. Mesh boundaries were also better defined along the IHNC, GIWW, and Bayou Bienvenue. The vertical datum for this mesh is NAVD 88 (2004.65). This Base mesh is identical to that used for the hydrodynamic modeling and particle tracking simulations as documented in Tate et al. 2010. The model validation is also included in the referenced document. From the Base mesh, the requested plan conditions are incorporated.

Boundary Conditions

Boundary conditions for this model include river inflows, tidal water surface elevations, and wind forcings. This information is needed for August 2007 through October 2008 in order to perform the requested analyses.

The river inflows to the model domain are taken from the U.S. Geologic Survey streamflow database. Daily average values are applied to the model at six locations: the Pearl River, the Amite River, the Blind River, the Tchefuncte River, the Tickfaw River, and the Tangipahoa River. The locations of these rivers are shown in Figure 2-2. Flow from the Mississippi River into the Gulf of Mexico is accounted for in the tidal boundary condition since it does not enter directly into the model domain. Ungaged flows are not factored into the model, which includes any flow through the wetland areas along the Mississippi River.

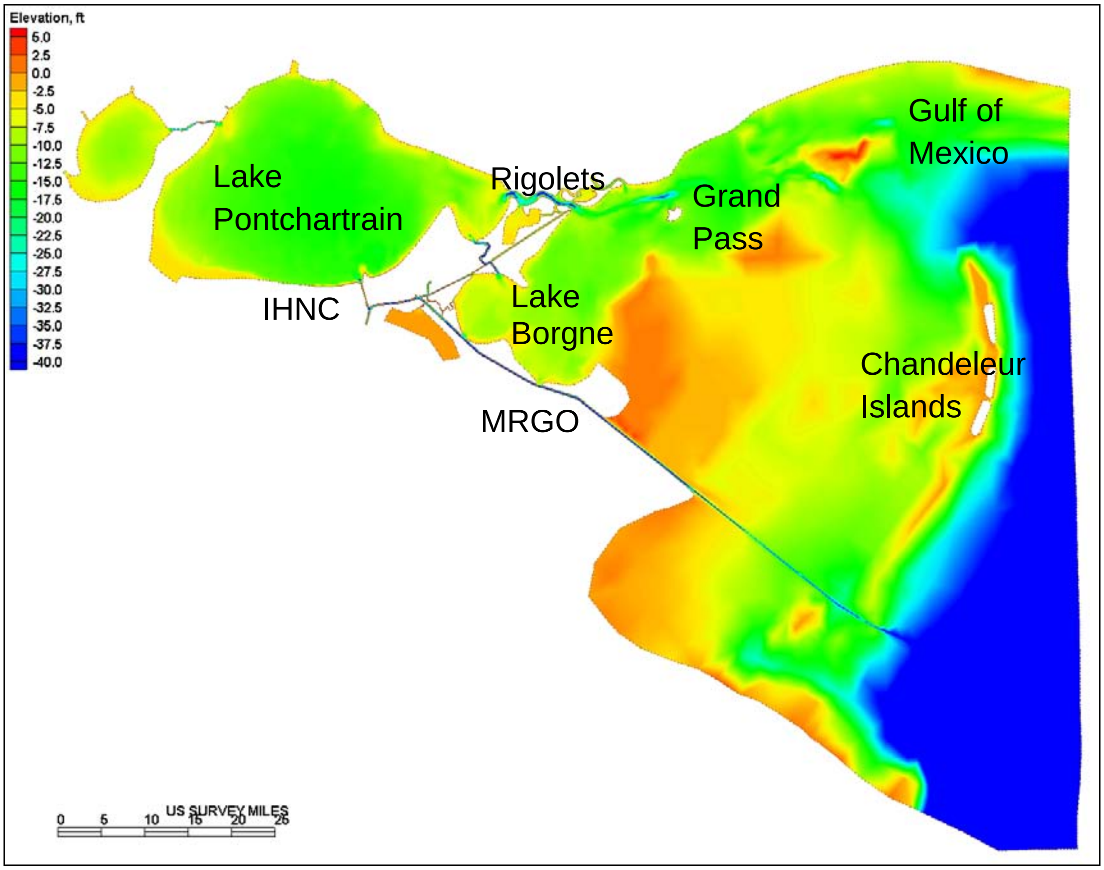


Figure 2-1. Model domain and bathymetry.

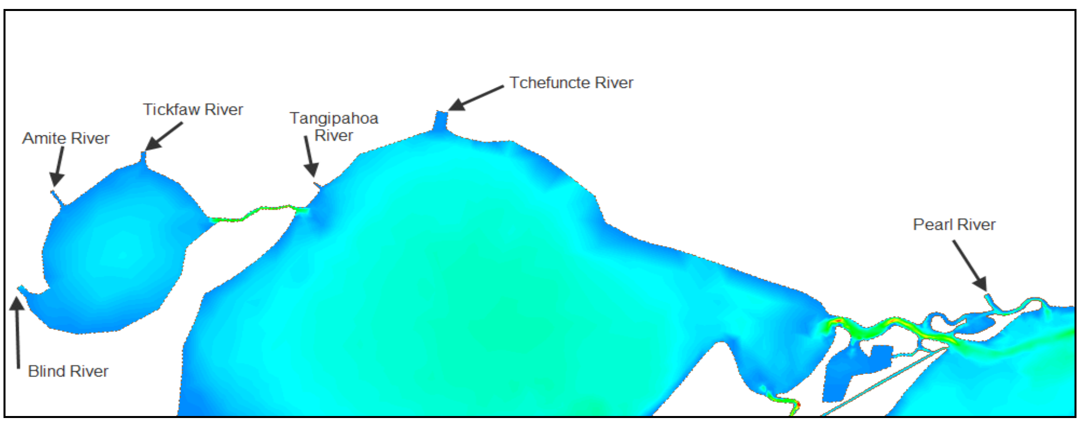


Figure 2-2. Location of river inflows.

The tidal forcings for the hydrodynamic model are generated using 2008 NOAA gage data from Gulfport Harbor (gage #8745557) and Pilots Station East, SW Pass (gage #8760922). The harmonic constituents and the nonastronomical, or sub-tidal, signal for each station are used to generate a tidal forcing or water surface elevation at each node along the tidal boundary over the time of the simulation. The values for each node are determined by performing a linear interpolation of the amplitude and phase

for each tidal constituent as well as for the sub-tidal signal. The tide is then reconstituted at each location along the boundary using these interpolated parameters. Again, details of this process and more information of the tidal boundary condition are available in Tate et al. 2010.

The wind data used were obtained from the Joint Air Force and Army Weather Information Network and the Air Force Combat Climatology Center in Ashville, NC. These data are hourly surface winds at the New Orleans International Airport (Station 722310 – KMSY). The wind signal is interpolated using a polynomial interpolation for the wind signal components to fill any data gaps.

Model Validation

The model is validated with field data from 2008 of water surface elevation, discharge, and velocity. Details of the model validation can be found in Tate et al. 2010, including boundary condition development and comparison of model results to the available field data.

3 Construction Sequence Plans

Model Scenarios

Two construction plan simulations are modeled in addition to the previous modeling efforts described in Tate et al. 2010. The two scenarios are modeled according to the analysis conditions requested by HPO in Tate et al. 2010 and the hydrodynamic results are provided to HPO. These results will be compared to an existing condition in which all waterways are open (Base), a plan condition in which the MRGO is closed at La Loutre (Plan 1), and a plan in which the MRGO is closed at La Loutre and south of Bayou Bienvenue and gate structures exist on the Bayou Bienvenue and GIWW (Plan 2). These conditions are labeled to correspond to the same conditions in the previous research and reports and details of these plans are given in the list below.

- Base - fully open MRGO, GIWW, and IHNC (Figure 3-1)

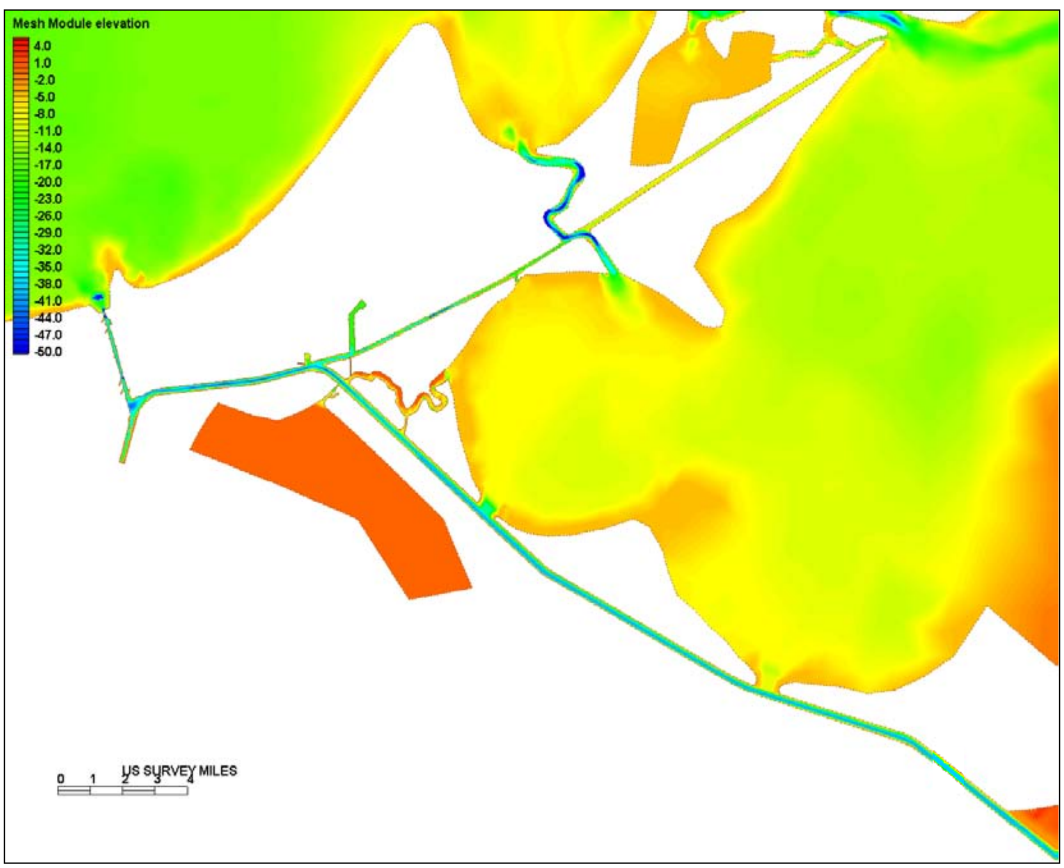


Figure 3-1. Base configuration: no closures, no structures.

- Plan 1 – close the MRGO at La Loutre (Figure 3-2)
- Plan 2 – close the MRGO at La Loutre, include the Borgne alignment (close the MRGO south of Bayou Bienvenue, 56 ft X 8 ft gate on Bayou Bienvenue, and two 150 ft X 16 ft gates on GIWW) (Figure 3-3)

The two construction sequences are intended to show how the actual construction process may affect the flows and water surface elevations in the surrounding areas of the system. While constructing these hurricane protection structures, cofferdams will be in place at various times, restricting the amount of flow passing certain locations, at times completely cutting off the channel. These cofferdams will be labeled as a closed pathway in the following figures. The construction sequence conditions are given in the following list.

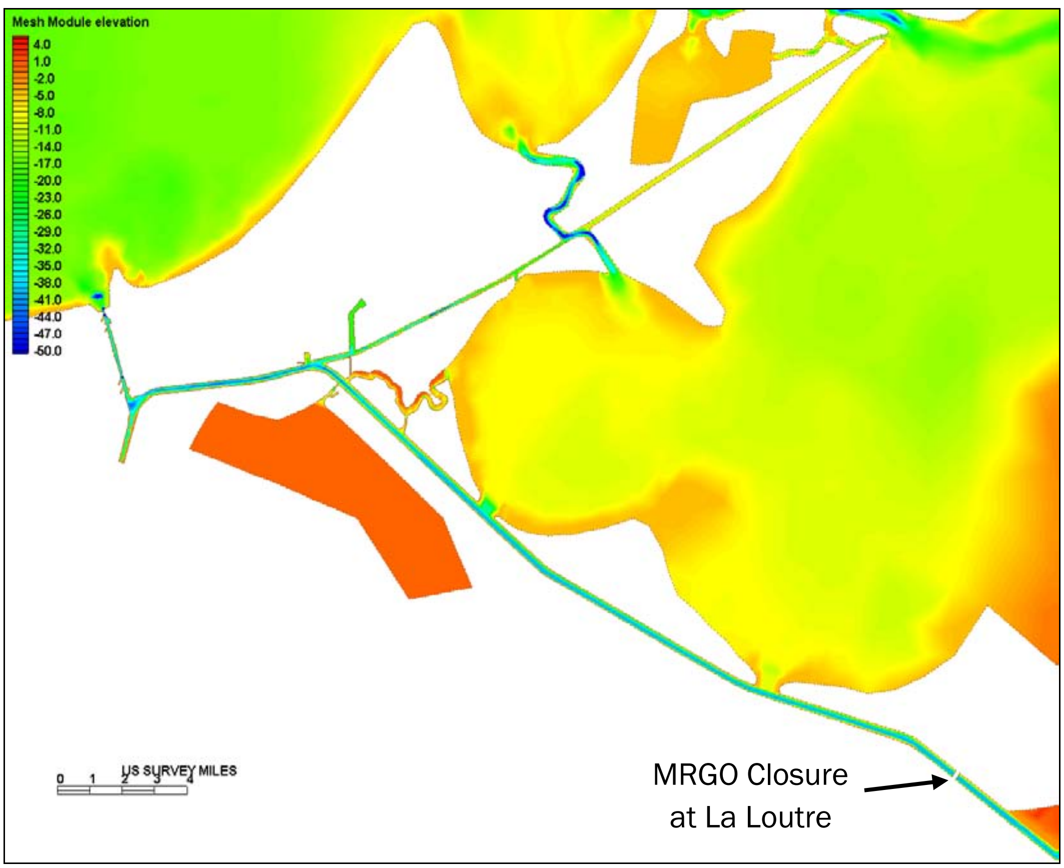


Figure 3-2. Plan 1 configuration: close the MRGO at La Loutre.

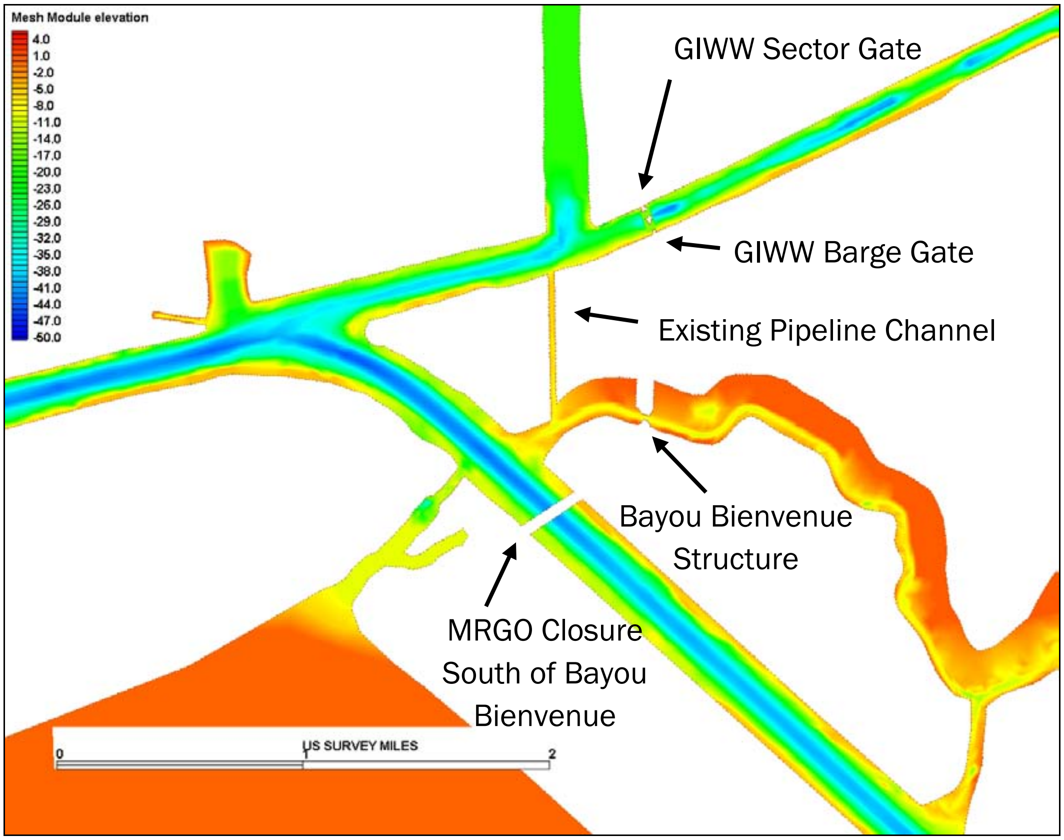


Figure 3-3. Plan 2 configuration: includes Plan 1 and the Borgne alignment (56 ft X 8 ft gate on Bayou Bienvenue, and two 150 ft X 16 ft gates on GIWW).

- February 2010 – close the MRGO at La Loutre, close the MRGO south of Bayou Bienvenue, cofferdam at the 56 ft X 8 ft gate on Bayou Bienvenue, cofferdam at the 150 ft X 16 ft sector gate on GIWW, open the 150 ft X 16 ft barge gate on GIWW, Seabrook area unchanged from Base (Figure 3-4)

- March 2010 - close the MRGO at La Loutre, close the MRGO south of Bayou Bienvenue, cofferdam at the 56 ft X 8 ft gate on Bayou Bienvenue, cofferdam at the 150 ft X 16 ft sector gate on GIWW, open the 150 ft X 16 ft barge gate on GIWW, Seabrook opening completely closed off for flow with cofferdam (Figure 3-5)

The hydrodynamic simulations for all conditions are run for two different time periods. Each analysis period is four weeks. A two week spin-up period is included in the hydrodynamic simulations prior to the analysis period. The two time periods used for this study are August 15 – September 15, 2007 (labeled as September) and March 1 – 31, 2008. A

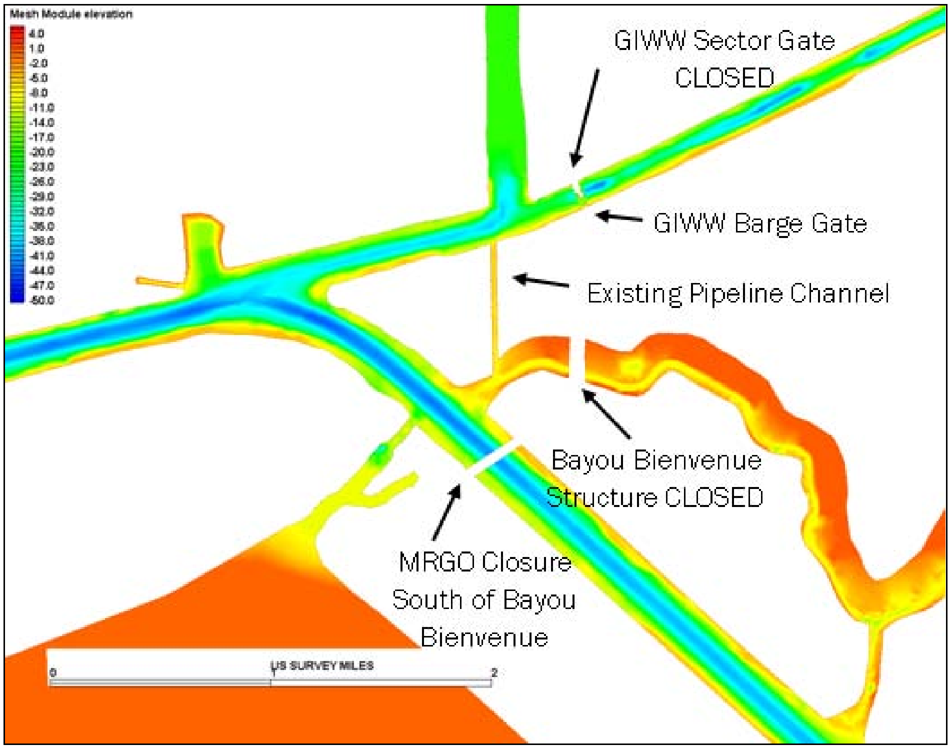


Figure 3-4. February 2010 configuration: close the MRGO at La Loutre, close the MRGO south of Bayou Bienvenue, cofferdam at the Bayou Bienvenue gate, cofferdam at the sector gate on GIWW, and open the 150 ft X 16 ft barge gate on GIWW.

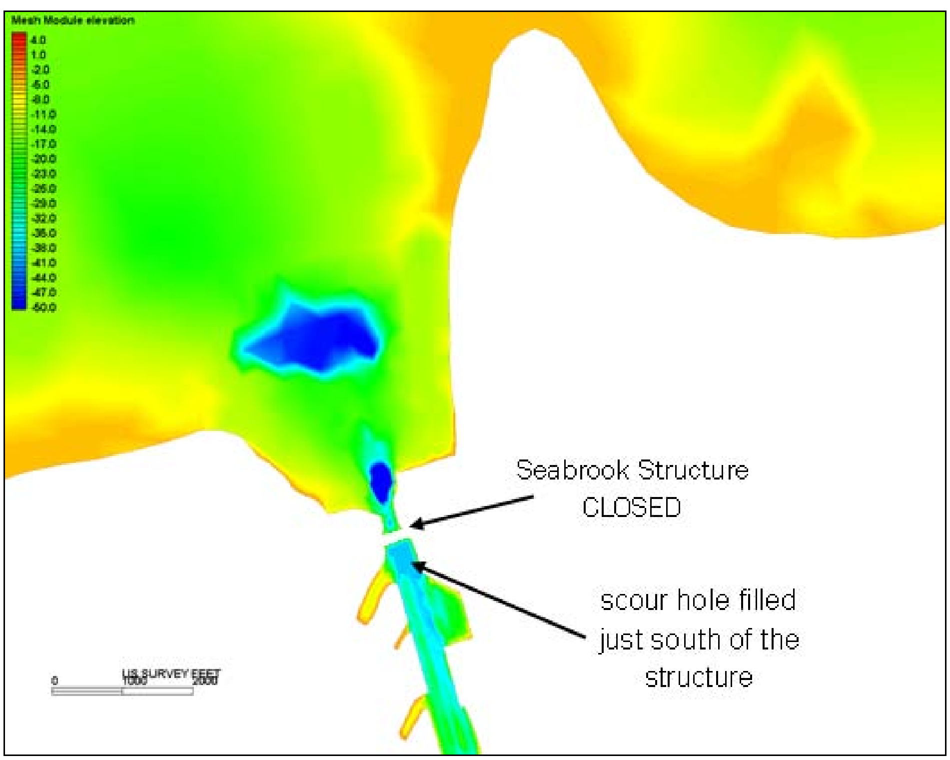


Figure 3-5. March 2010 configuration: includes February 2010 configuration with a cofferdam at the Seabrook structure as well.

general picture of the tidal signal near the Gulf boundary for these two time periods is shown in Figures 3-6 and 3-7. The wind speeds at the New Orleans International Airport for these periods are given in Figures 3-8 and 3-9. It is apparent in these figures that the March winds and tide are indicative of the spring season when conditions are more erratic due to front passages and rain events. The September period shows lower wind speeds and a more typical diurnal tide signal, which is expected in the Gulf of Mexico.

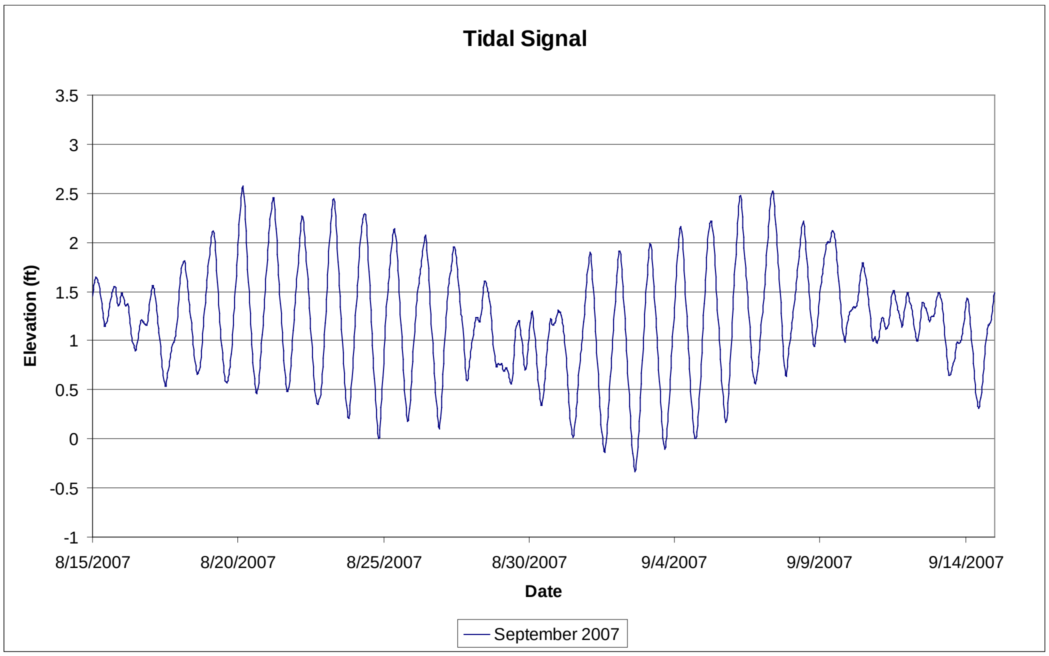


Figure 3-6. Tide signal for the September analysis period.

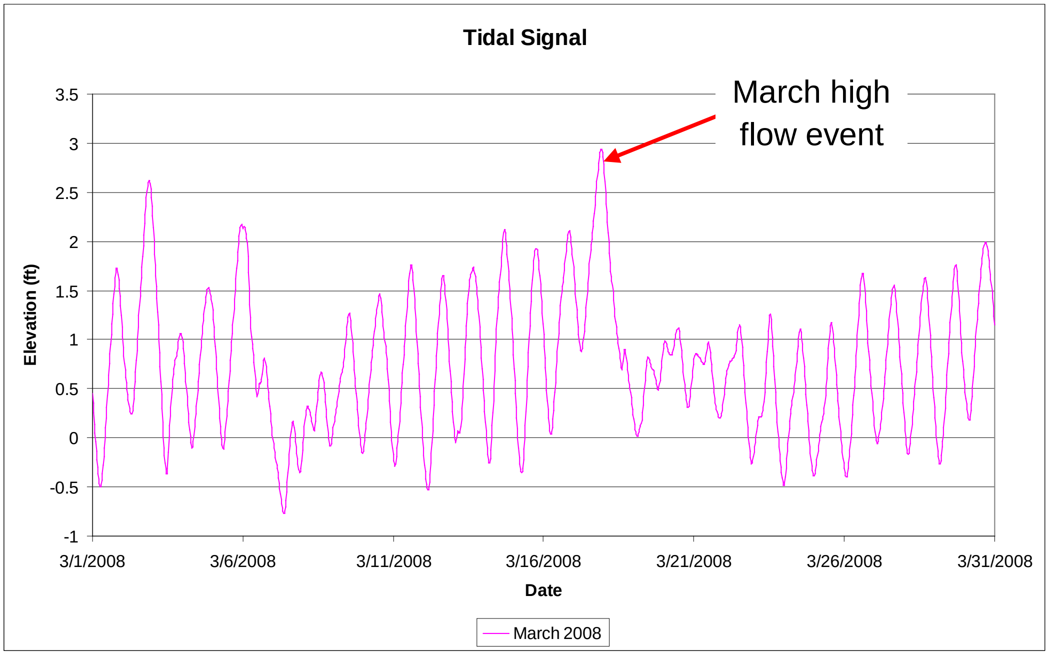


Figure 3-7. Tide signal for the March analysis period.

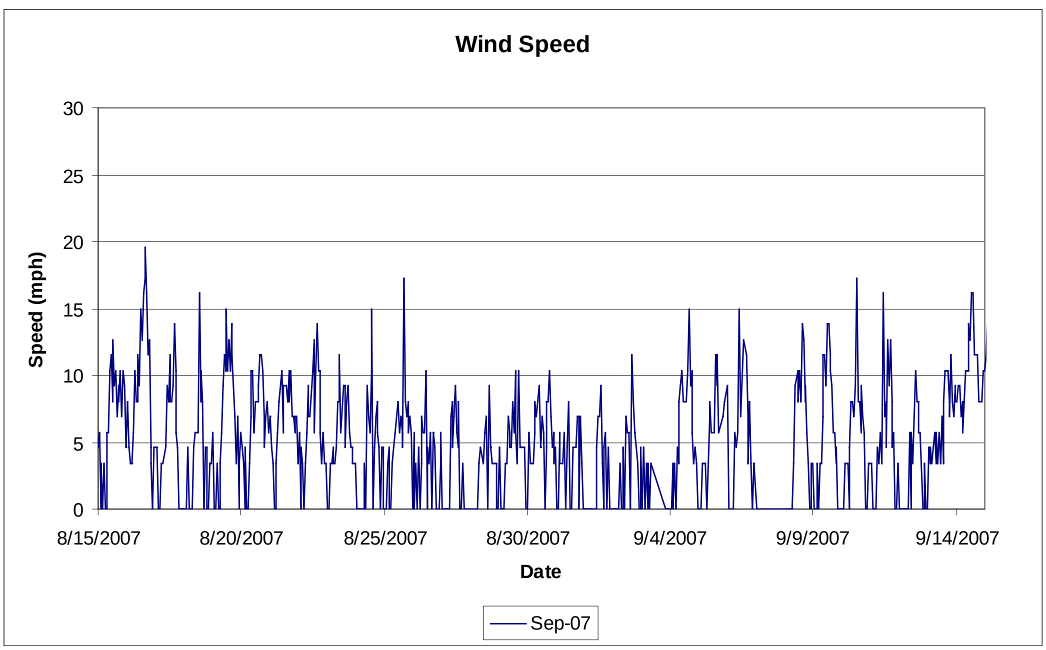


Figure 3-8. Wind signal for the September analysis period.

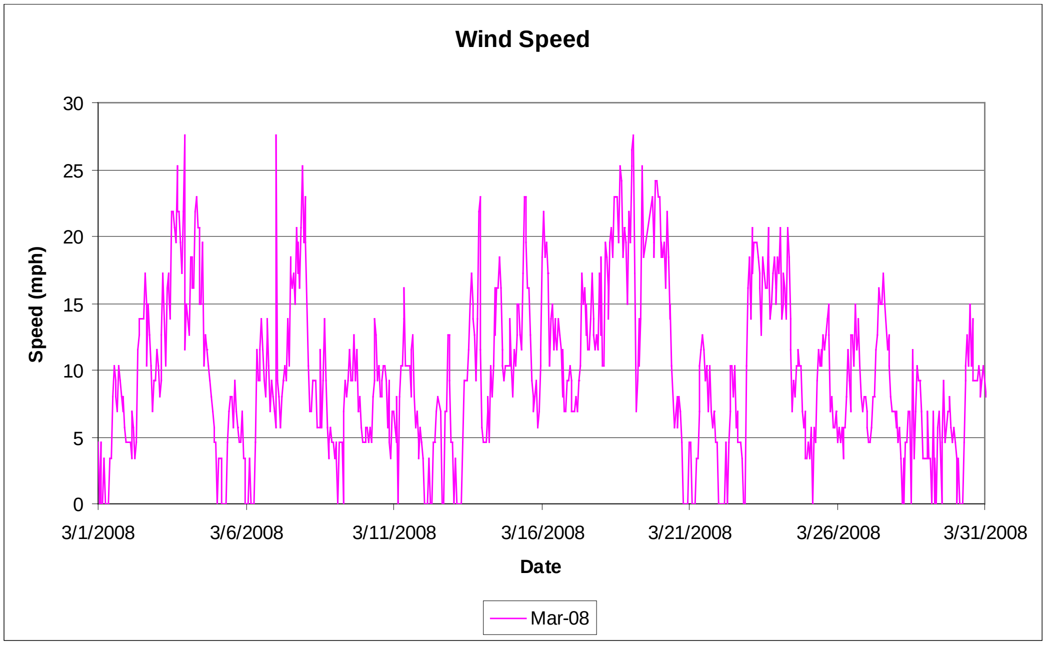


Figure 3-9. Wind signal for the March analysis period.

4 Hydrodynamic Results

The results of the hydrodynamic simulations are presented here. An analysis of how the construction sequence plan conditions affect the velocities and water surface elevations in the area of the structures is given in this section.

Velocity Magnitudes

Velocity data are extracted in the location of the structures for the GIWW barge gate and the Seabrook structure. Data are not extracted in the Bayou Bienvenue structure or at the GIWW sector gate since there is a cofferdam in place at these locations. Since there is also a cofferdam at the Seabrook structure in the March 2010 condition, no data is presented for that situation. Data are also compared at locations in Chef Menteur and the Rigolets. Figures 4-1 through 4-3 show the locations of velocity data comparisons. For the Base, Plan 1, and Plan 2 comparison conditions, data are analyzed at a location north of the Seabrook structure location where the velocities are greatest.

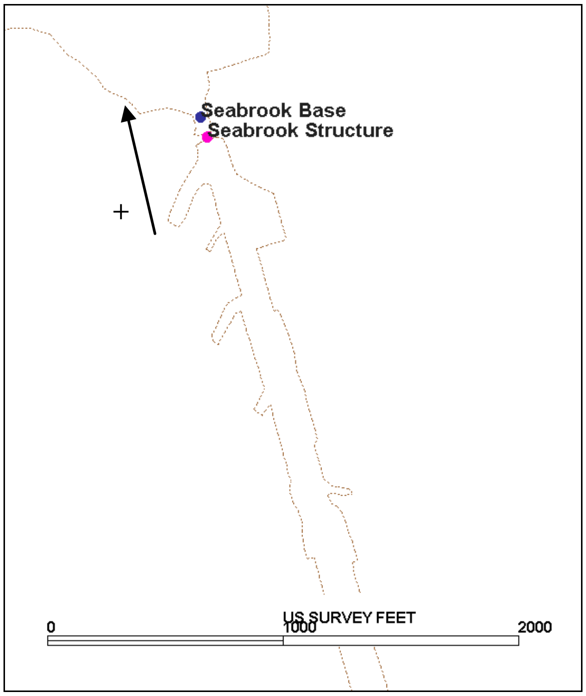


Figure 4-1. Hydrodynamic analysis locations – Seabrook.

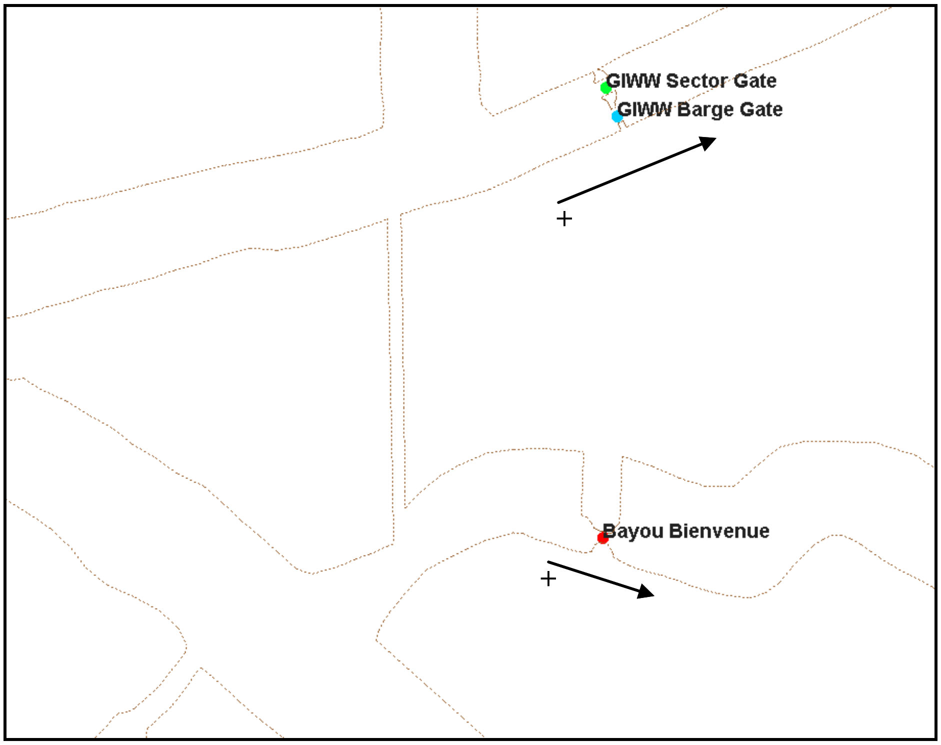


Figure 4-2. Hydrodynamic analysis locations – Bayou Bienvenue Structure, GIWW Sector Gate, and GIWW Barge Gate.

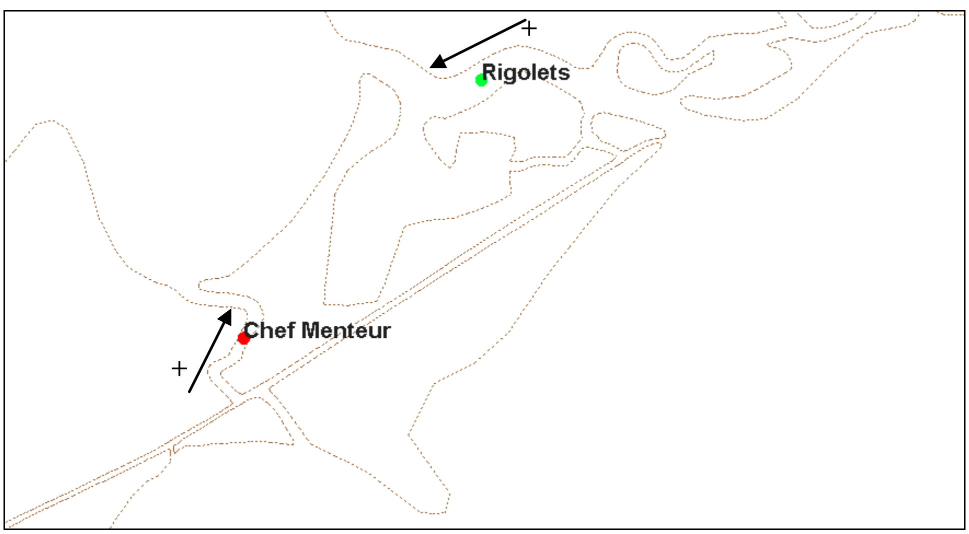
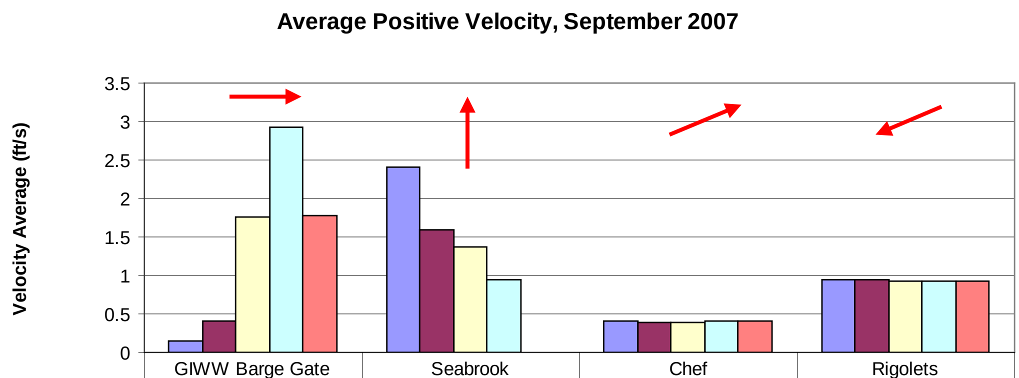


Figure 4-3. Hydrodynamic analysis locations – Chef Menteur and Rigolets.

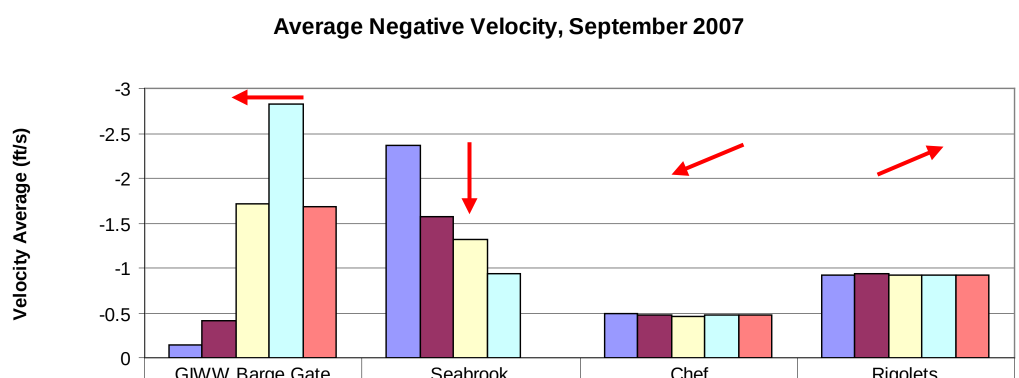
The average velocity for flood and ebb are determined at each location and time period for all simulation conditions as are the maximum velocities for all conditions. Since there is a circulation within this system through the GIWW, the definition of flood and ebb can be misleading. For this reason a definition of positive and negative or flood and ebb is necessary. Positive

values are defined as those directed predominantly toward the north or east and negative values are defined as those directed predominantly toward the south or west, except at the Chef Menteur and Rigolets where positive flow is into Lake Pontchartrain and negative flow is toward the GIWW or Lake Borgne. The arrows in Figures 4-1 through 4-3 show the positive direction for each location. The results of this analysis are given in Figures 4-4 through 4-11. A direction arrow is included for each location to help define the flow direction.



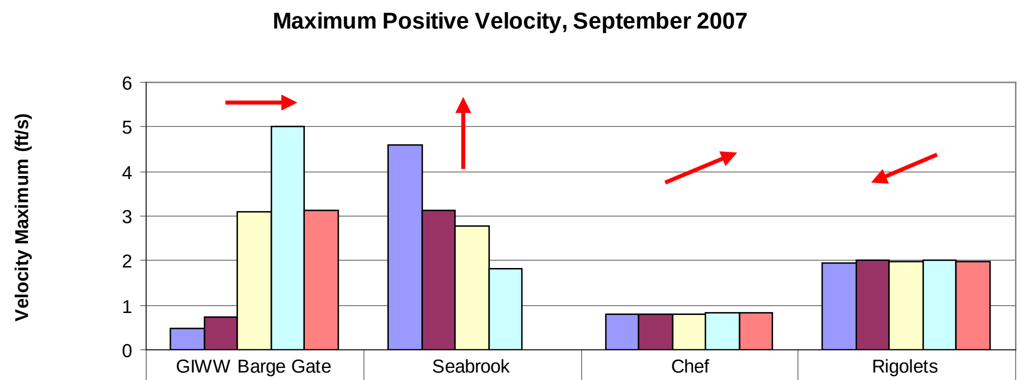
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.15	2.41	0.41	0.95
Plan 1	0.41	1.59	0.40	0.95
Plan 2	1.75	1.37	0.39	0.92
Feb 2010	2.93	0.94	0.40	0.93
Mar 2010	1.78	0.00	0.40	0.92

Figure 4-4. Velocity average for September (positive).



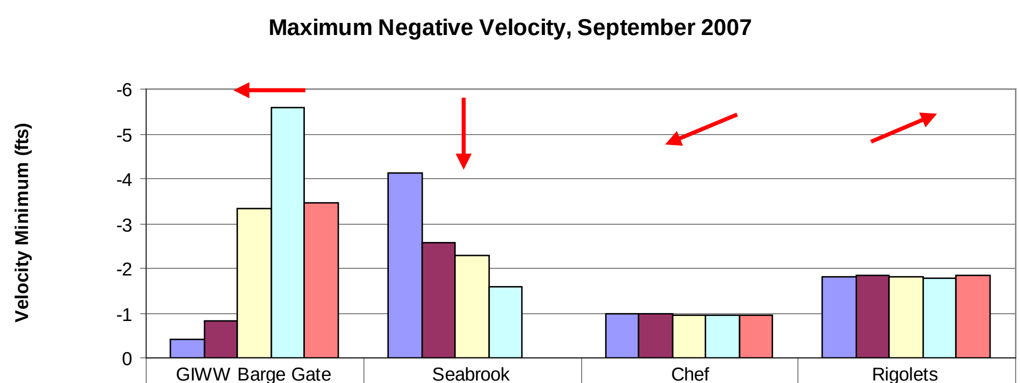
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.15	-2.36	-0.49	-0.92
Plan 1	-0.41	-1.57	-0.47	-0.93
Plan 2	-1.72	-1.32	-0.47	-0.92
Feb 2010	-2.83	-0.94	-0.47	-0.92
Mar 2010	-1.69	0.00	-0.48	-0.92

Figure 4-5. Velocity average for September (negative).



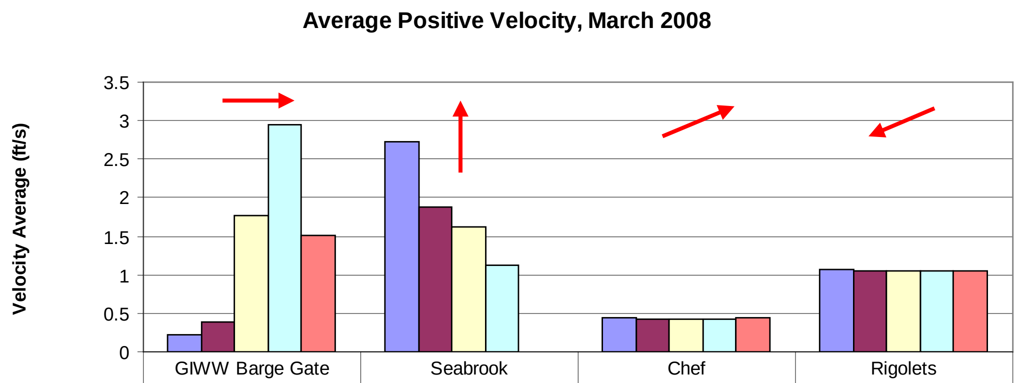
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.47	4.58	0.81	1.94
Plan 1	0.73	3.12	0.80	2.00
Plan 2	3.08	2.77	0.80	1.97
Feb 2010	5.03	1.83	0.82	2.00
Mar 2010	3.14	0.00	0.82	1.98

Figure 4-6. Velocity maximum for September (positive).



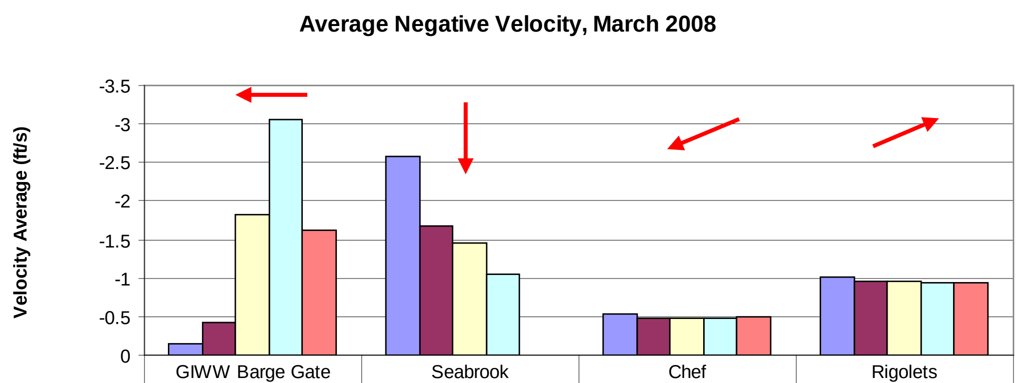
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.41	-4.13	-0.97	-1.80
Plan 1	-0.84	-2.58	-0.98	-1.85
Plan 2	-3.34	-2.28	-0.95	-1.80
Feb 2010	-5.60	-1.60	-0.94	-1.79
Mar 2010	-3.45	0.00	-0.96	-1.84

Figure 4-7. Velocity minimum for September (negative).



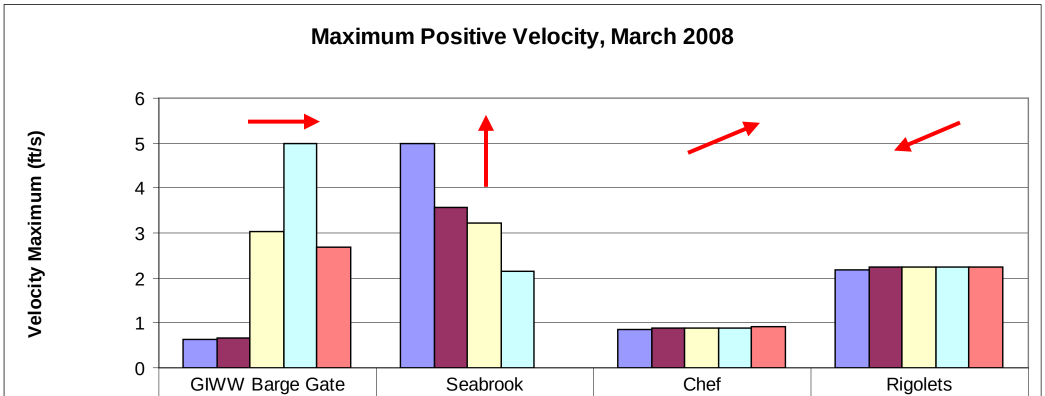
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.21	2.73	0.45	1.08
Plan 1	0.39	1.87	0.43	1.05
Plan 2	1.76	1.62	0.43	1.05
Feb 2010	2.95	1.12	0.43	1.04
Mar 2010	1.52	0.00	0.44	1.05

Figure 4-8. Velocity average for March (positive).



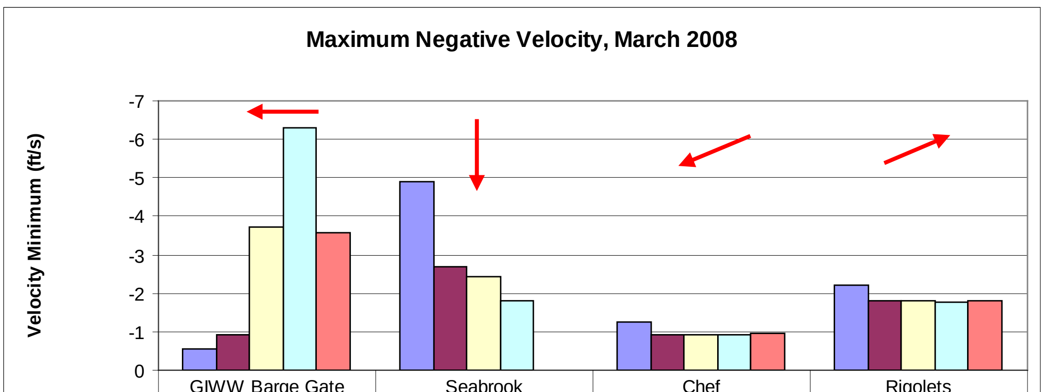
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.14	-2.59	-0.54	-1.02
Plan 1	-0.42	-1.68	-0.48	-0.97
Plan 2	-1.83	-1.46	-0.48	-0.96
Feb 2010	-3.05	-1.05	-0.48	-0.95
Mar 2010	-1.62	0.00	-0.50	-0.95

Figure 4-9. Velocity average for March (negative).



	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.64	4.98	0.86	2.17
Plan 1	0.67	3.57	0.88	2.24
Plan 2	3.02	3.23	0.87	2.24
Feb 2010	5.00	2.15	0.89	2.24
Mar 2010	2.68	0.00	0.91	2.25

Figure 4-10. Velocity maximum for March (positive).



	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.54	-4.89	-1.24	-2.21
Plan 1	-0.91	-2.69	-0.92	-1.82
Plan 2	-3.73	-2.45	-0.92	-1.81
Feb 2010	-6.30	-1.79	-0.92	-1.78
Mar 2010	-3.58	0.00	-0.96	-1.80

Figure 4-11. Velocity minimum for March (negative).

The February 2010 gate closure sequence included cofferdams at the GIWW sector gate and the Bayou Bienvenue gate (completely closing the waterway) along with both MRGO closures. This means that flow through the GIWW must pass through the 150 ft wide barge gate. By forcing all of the flow through this structure, the velocity increases greatly, as noted in the previous figures for both September and March. However, the velocities at Seabrook are reduced because the smaller width on the GIWW limits the amount of exchange at Seabrook. By making velocity comparisons at Chef Menteur and Rigolets, it can be determined how

widely the effects of the construction are felt. Based on the model results, the effects are limited to the area of the structures since there is very little change at Chef Menteur and Rigolets.

The March 2010 construction plan adds a cofferdam at Seabrook. By shutting off this entrance to Lake Pontchartrain, the overall water exchange between Lake Borgne and Lake Pontchartrain through the GIWW is reduced, as supported by the reduction in velocity at the GIWW barge gate. Again, the effects do not extend too far into the system since there are no significant changes in velocity at Chef Menteur and Rigolets.

The maximum velocity magnitudes, however, only occur during a small fraction of the simulation time. A percent less than analysis is performed to determine how often during the four week simulation periods the velocity magnitudes are within certain ranges. Figures 4-13 through 4-24 show the percent less than plots for the locations given in Figure 4-12. As with the previous analysis, data are not extracted at the Bayou Bienvenue structure or the GIWW sector gate since these locations are blocked of any flow. No data are given for the Seabrook structure in the March 2010 condition since a cofferdam is in place under this plan. These locations are the same as those in the previous velocity analysis (see Figures 4-1 to 4-3) as well as additional locations in Lake Borgne, Lake Pontchartrain, Chef Menteur, and the Rigolets. These plots show velocity magnitude on the x-axis and percentage of time on the y-axis. At the maximum velocity magnitude, the percentage is almost 100 since the velocity is equal to or less than this value over the length of the simulation. All lines cross zero at 0% since the velocity is always greater than zero. Where each line crosses 50% the velocity is greater half the time and less half the time over the four week analysis period.

The same patterns are seen in the percent less than analysis as in the analysis of velocity averages and extremes. The February 2010 plan generates increases in velocity at the GIWW barge gate but decreases at Seabrook. The March 2010 plan, however, reduces the velocity at the GIWW barge gate back to the values obtained with Plan 2. There are small changes in flow in Lake Pontchartrain and Lake Borgne, but the velocity values in these areas are less than or equal to the Plan 1 and Plan 2 values from the previous work (Tate et al. 2010). The same trends are observed for both the September 2007 and March 2008 analysis periods.

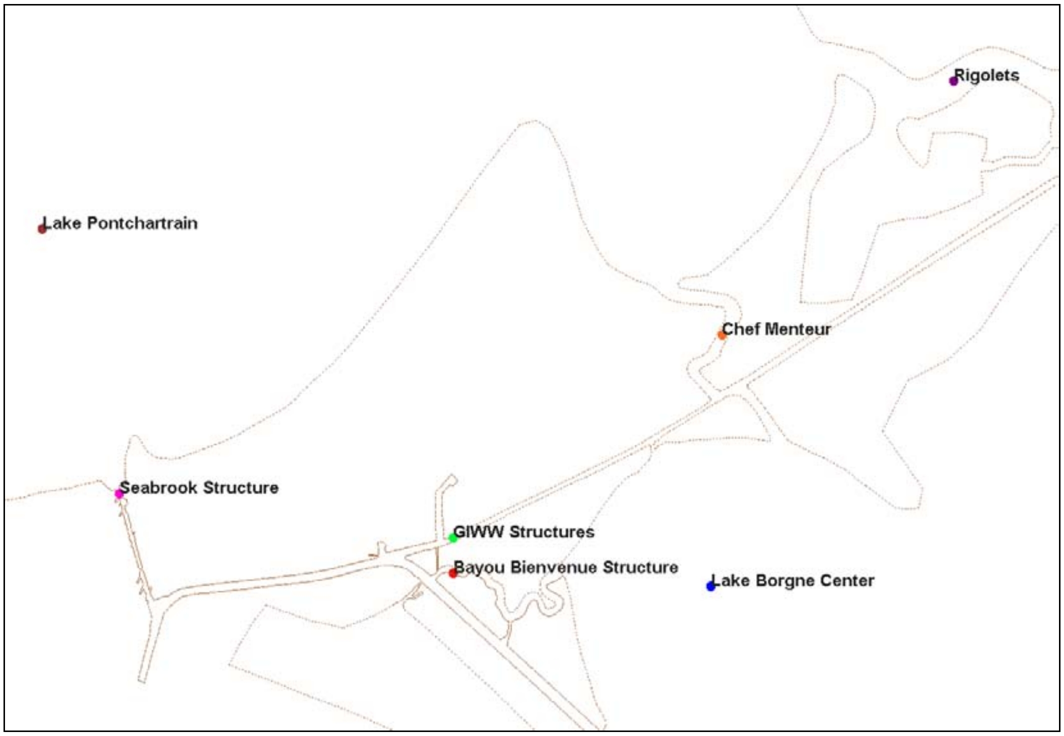


Figure 4-12. Percent less than of velocity magnitude analysis locations.

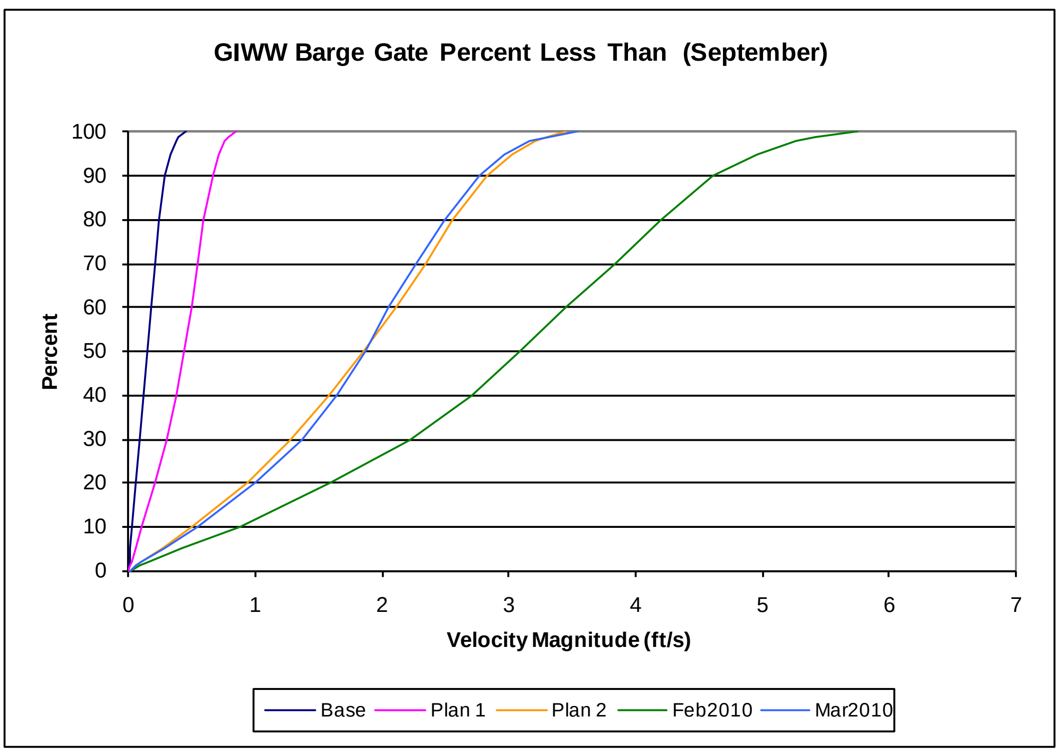


Figure 4-13. GIWW Barge Gate percent less than plot for September.

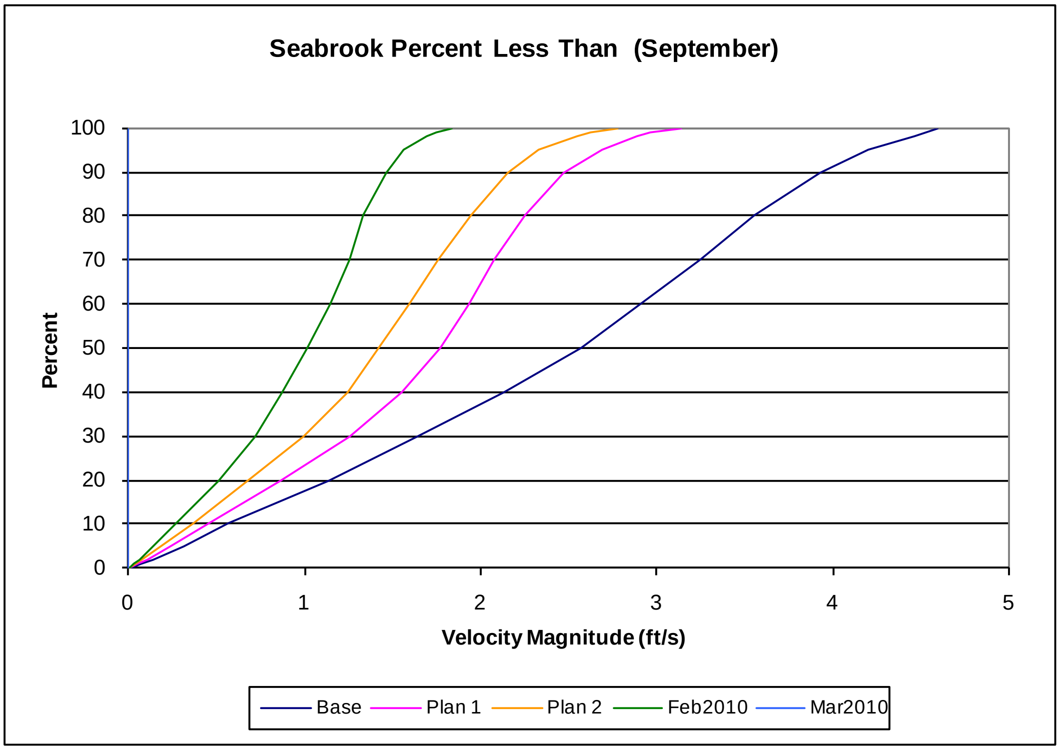


Figure 4-14. Seabrook percent less than plot for September.

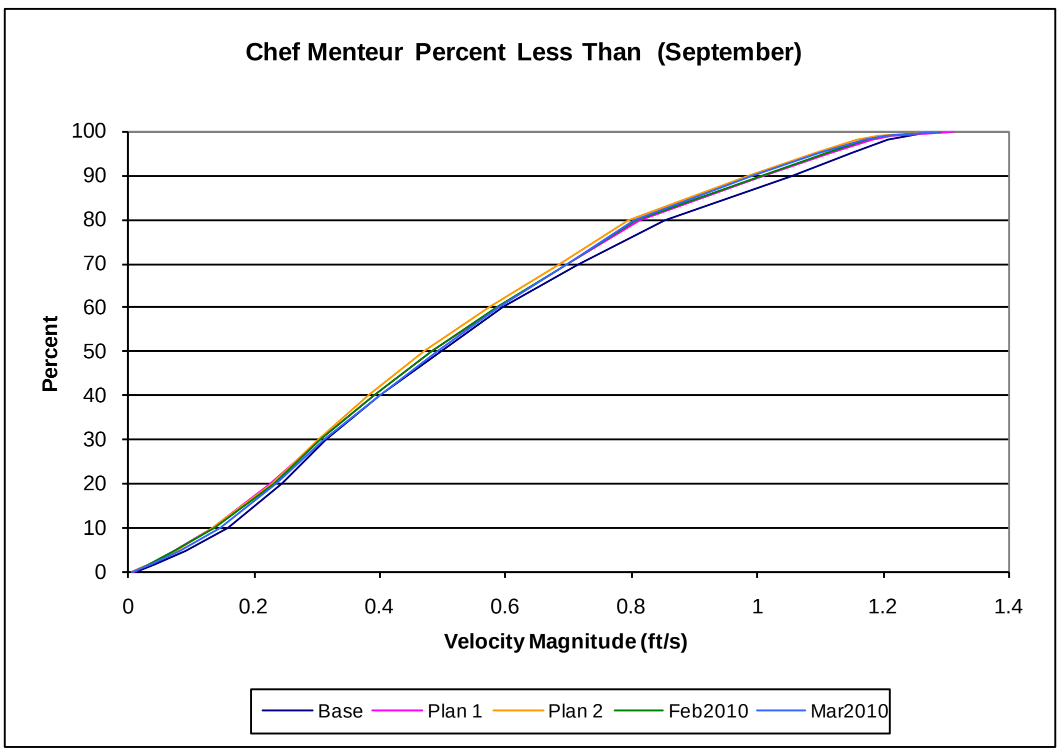


Figure 4-15. Chef Menteur percent less than plot for September.

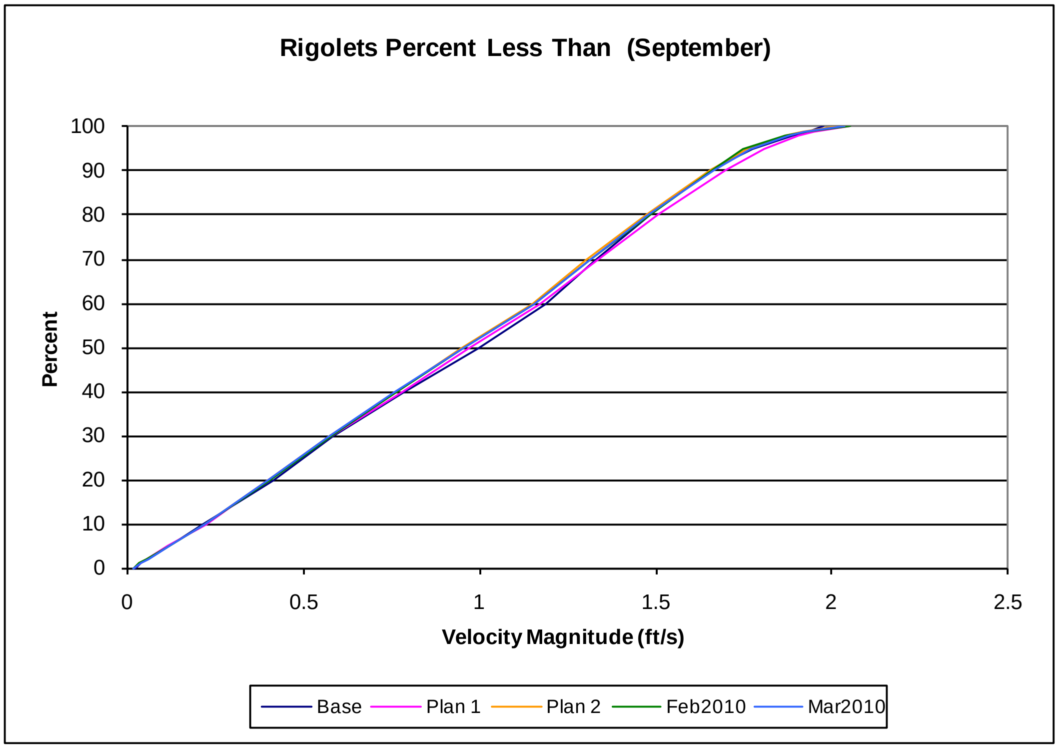


Figure 4-16. Rigolets percent less than plot for September.

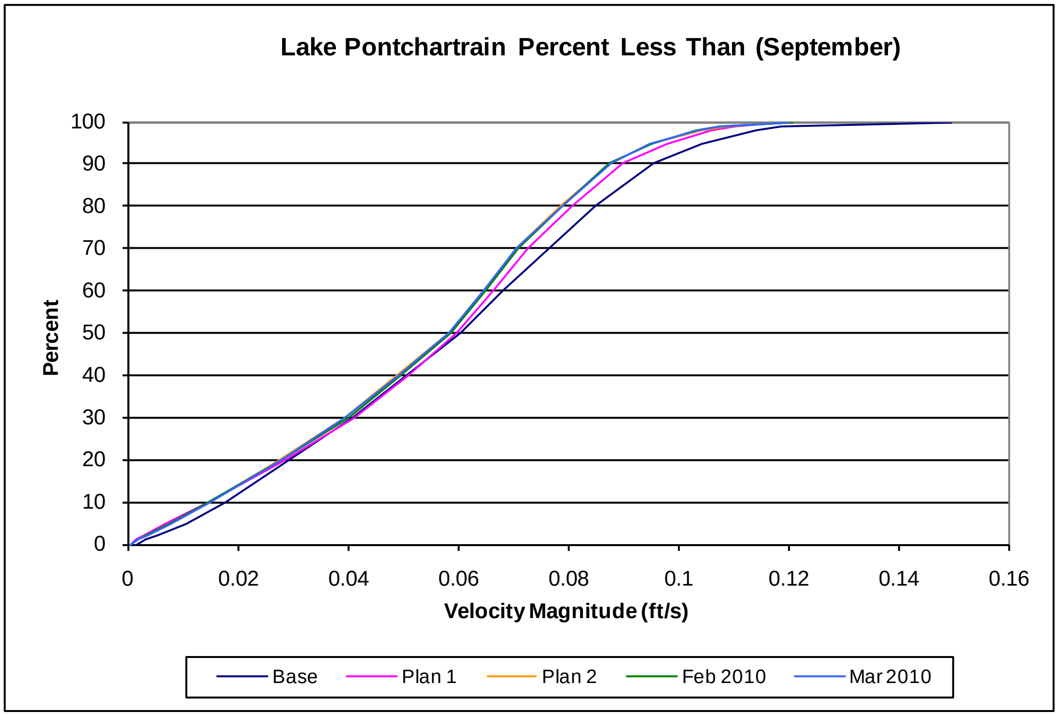


Figure 4-17. Lake Pontchartrain percent less than plot for September.

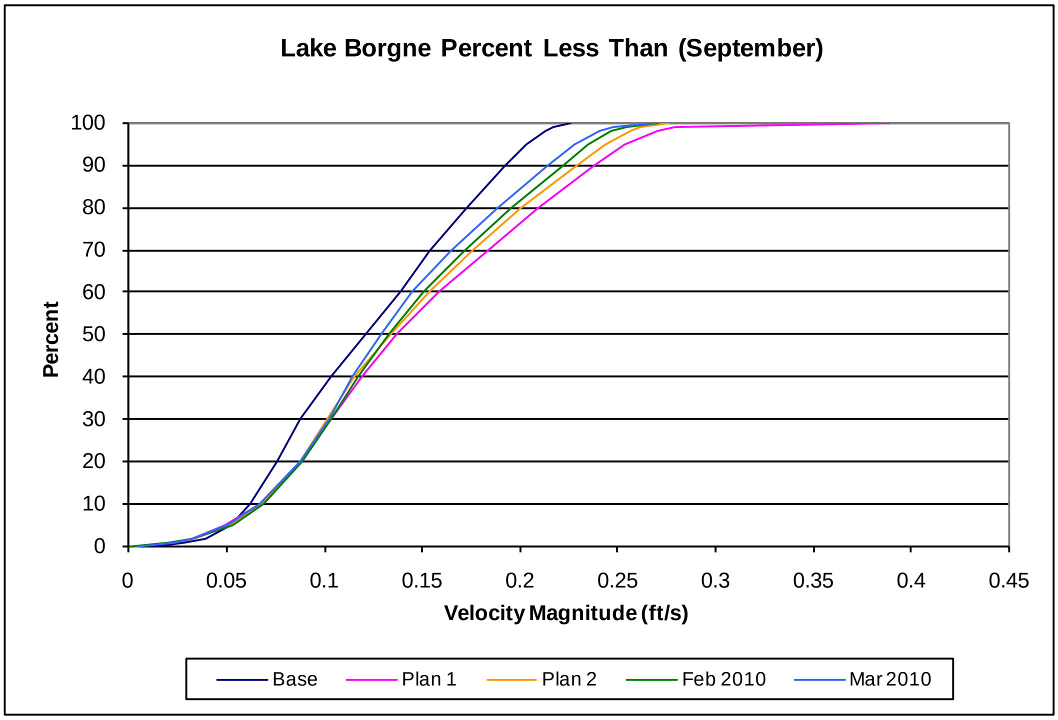


Figure 4-18. Lake Borgne percent less than plot for September.

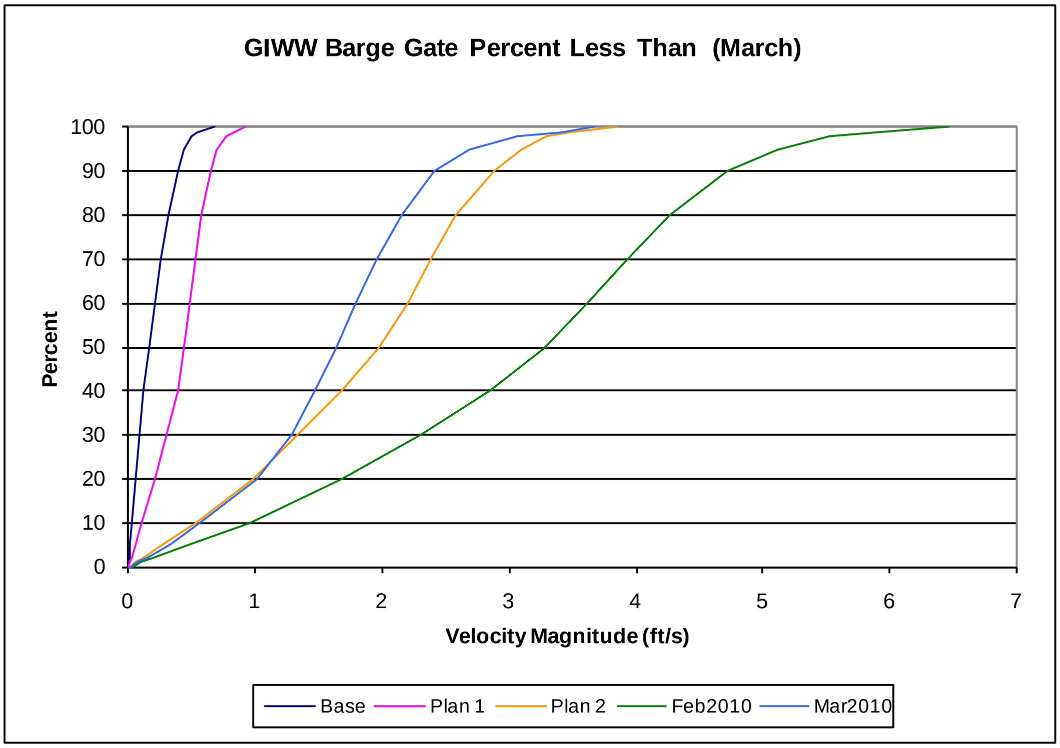


Figure 4-19. GIWW Barge Gate percent less than plot for March.

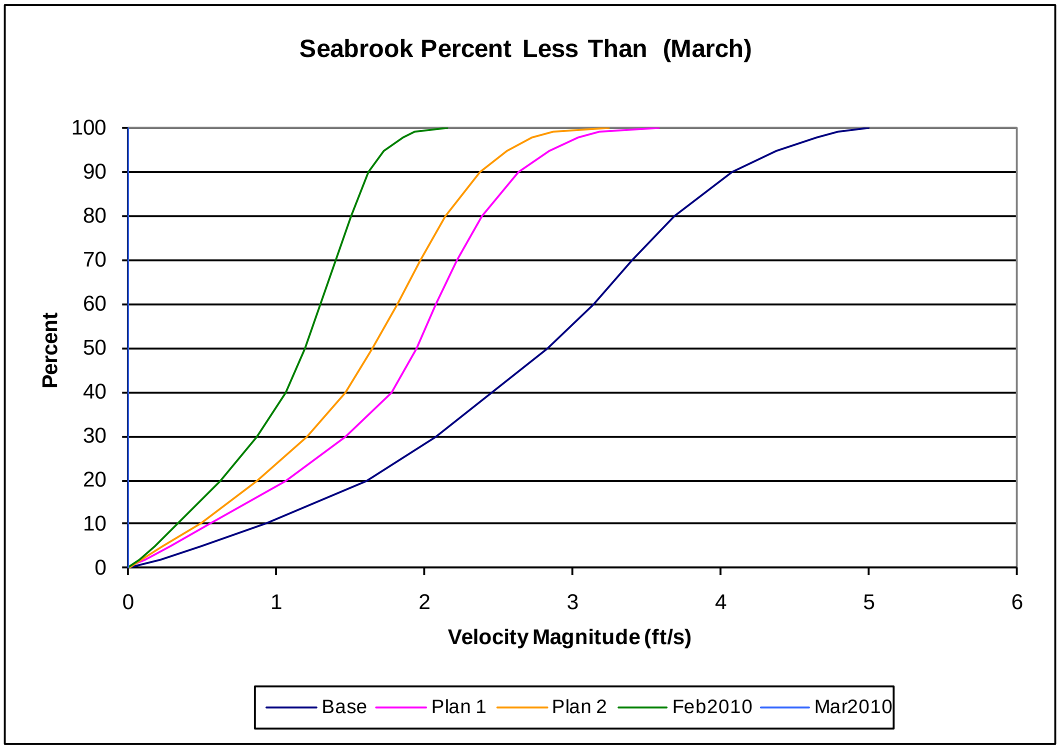


Figure 4-20. Seabrook percent less than plot for March.

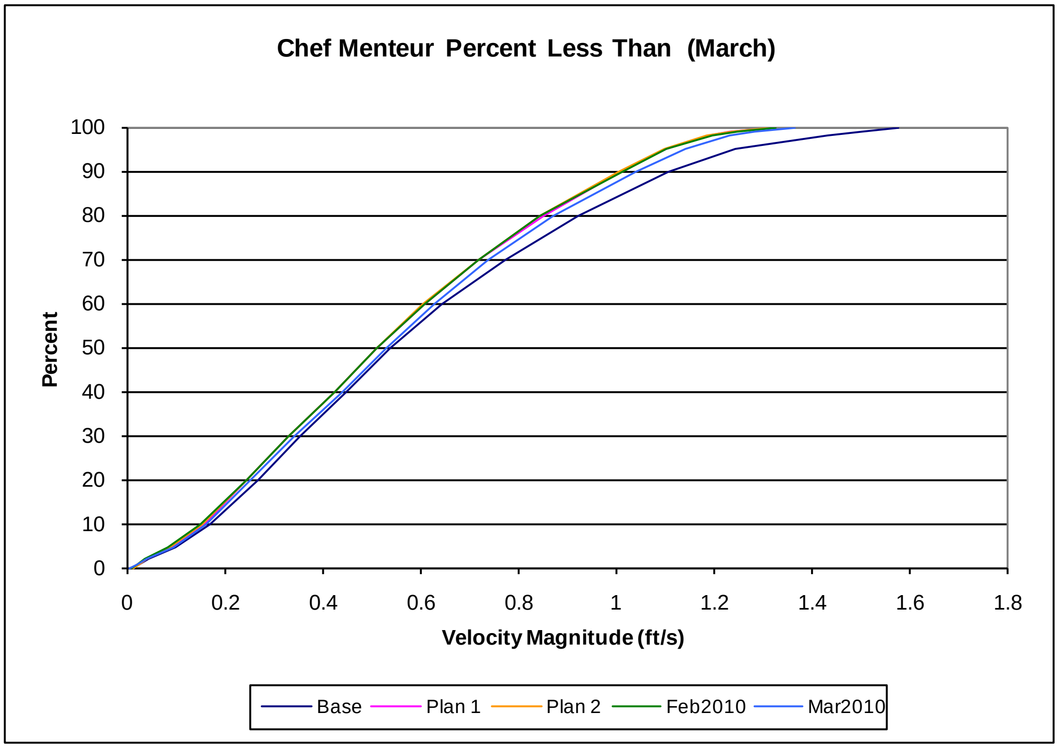


Figure 4-21. Chef Menteur percent less than plot for March.

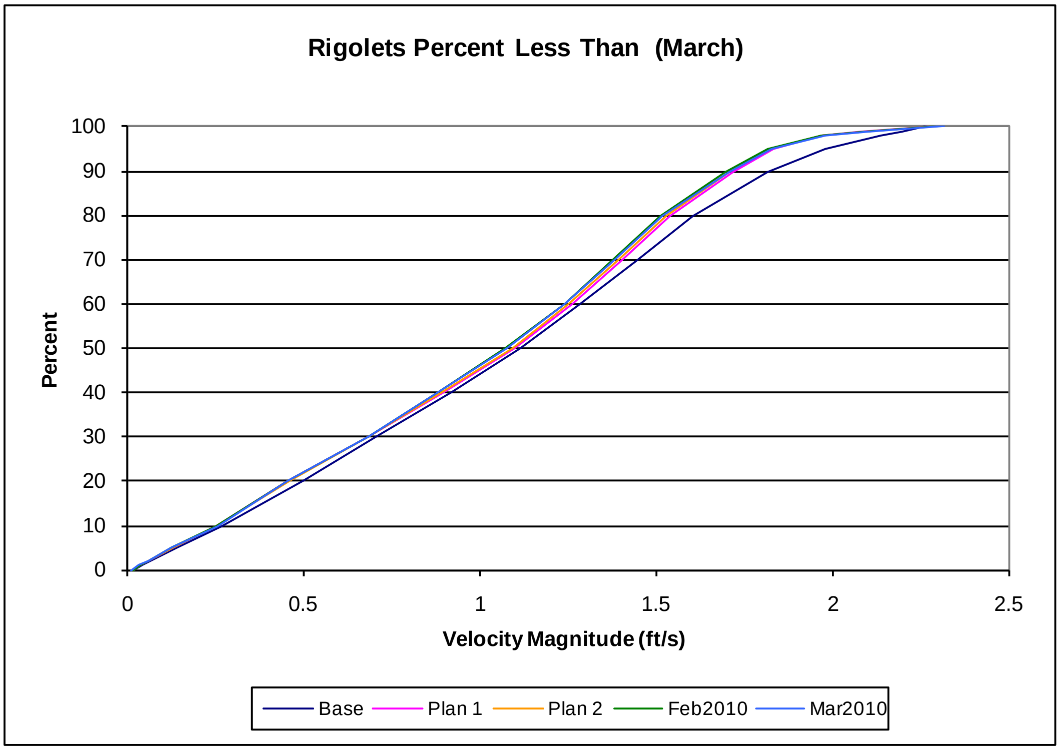


Figure 4-22. Rigolets percent less than plot for March.

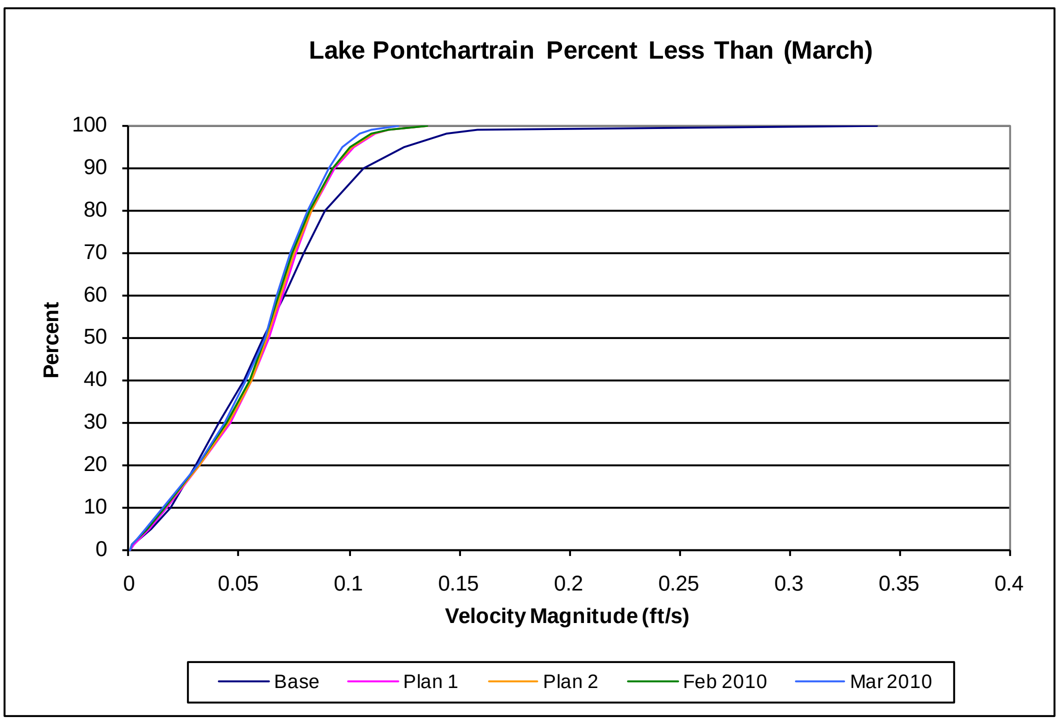


Figure 4-23. Lake Pontchartrain percent less than plot for March.

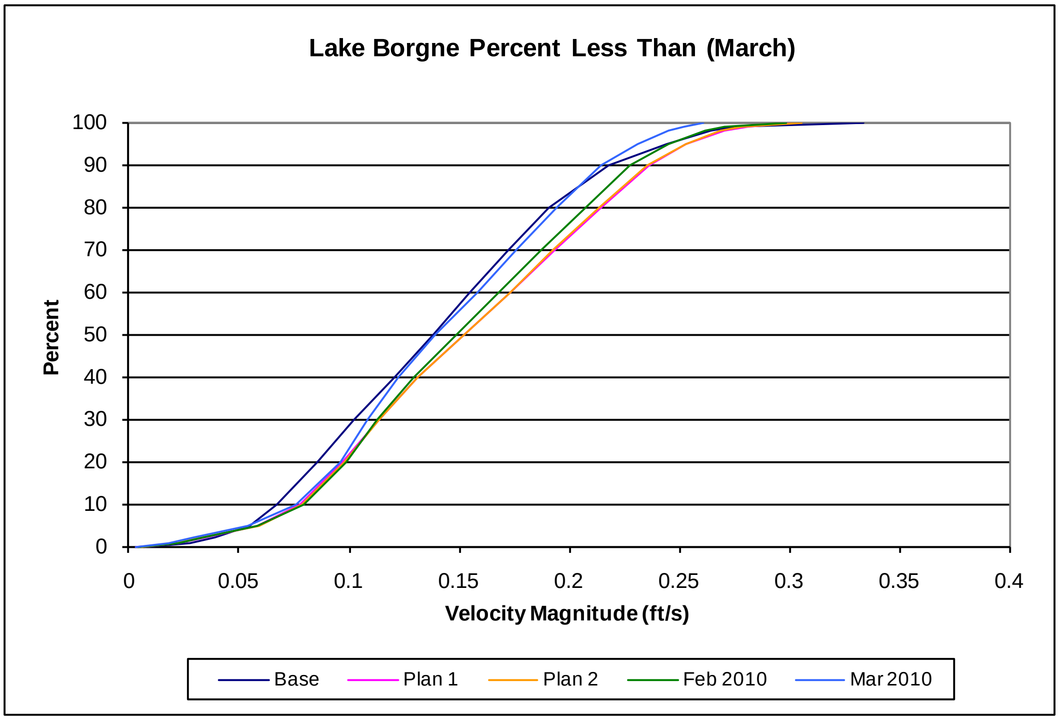


Figure 4-24. Lake Borgne percent less than plot for March.

Water Surface Analysis

A water surface elevation analysis is performed at a total of 16 points within the model domain. The initial locations are set at 250 ft to each side of a proposed structure. Six additional locations are chosen so that an overall response to the system due to the plan alternatives can be observed. Figures 4-25 and 4-26 show the analysis locations. Locations for each side of a structure are shown as a single point. This analysis is performed on both the September and March flow conditions. The water surface elevation for each location and alternative is shown in Figures 4-27 to 4-58. These figures display 12.5 days of the simulation (August 22 – September 3, 2007; March 9 - 21, 2008).

The water surface analysis indicates that there is very little change from the previous plan results for both construction sequence plans at the locations in Lake Borgne (Figures 4-40, 4-41, 4-56, and 4-57), Lake Pontchartrain (Figures 4-42 and 4-58), Chef Menteur (Figures 4-38 and 4-54), Rigolets (Figures 4-39 and 4-55), and locations surrounding the MRGO closure at La Loutre (Figures 4-27, 4-28, 4-43, and 4-44). However, this is not the case at locations in the area of the closures. For all water surface analyses, the same results are evident for both the September 2007 and March 2008 simulation periods.

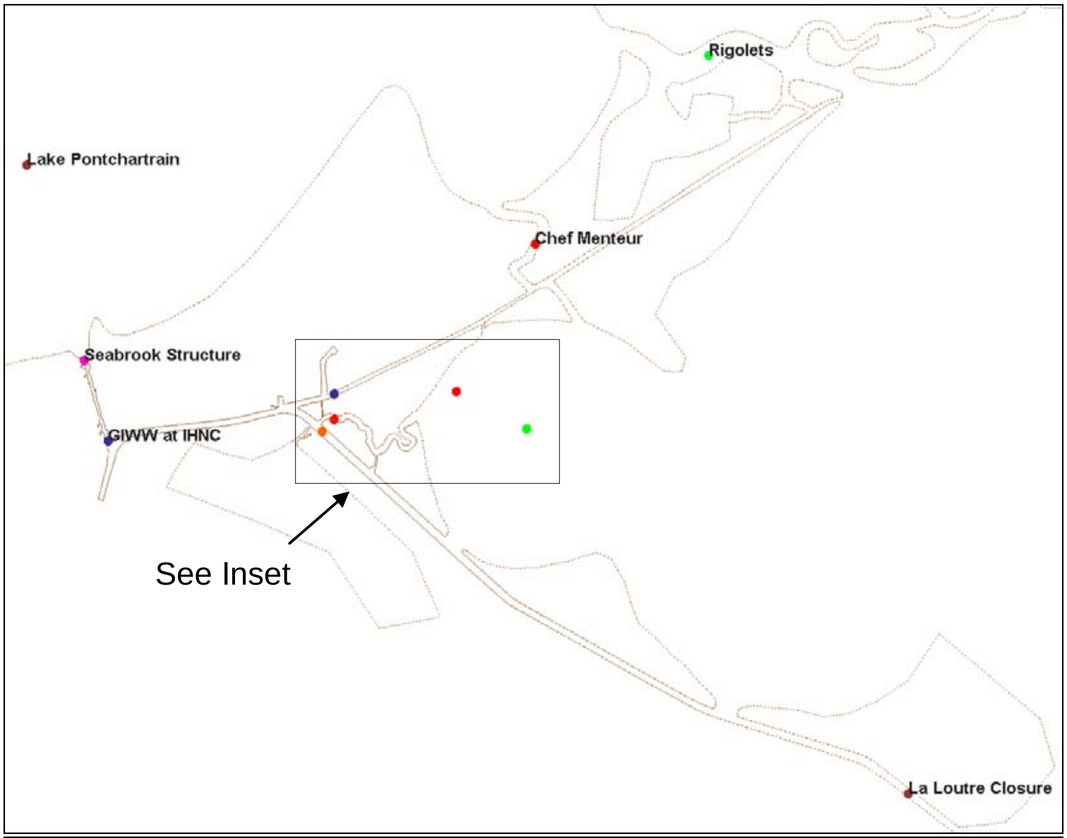


Figure 4-25. Location map for water surface analysis.

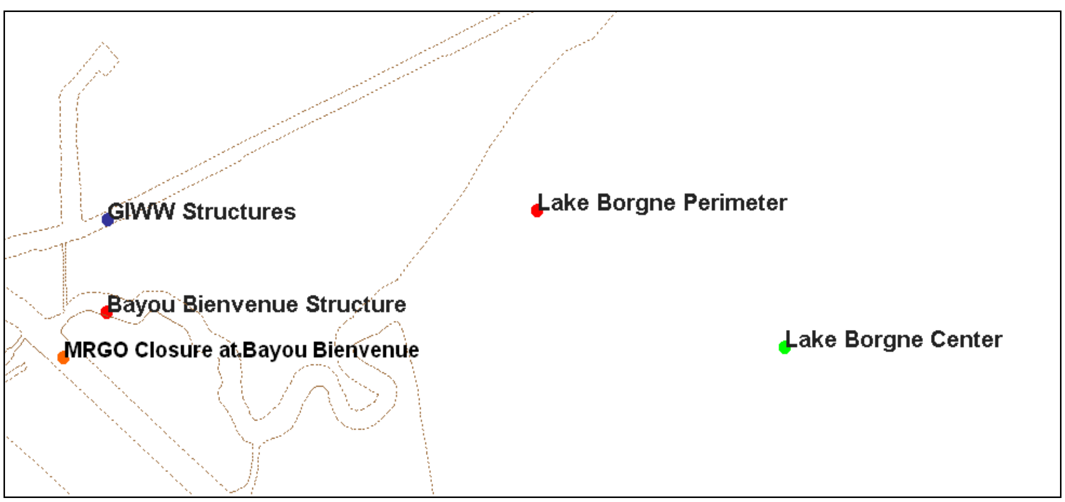


Figure 4-26. Inset for water surface analysis location map.

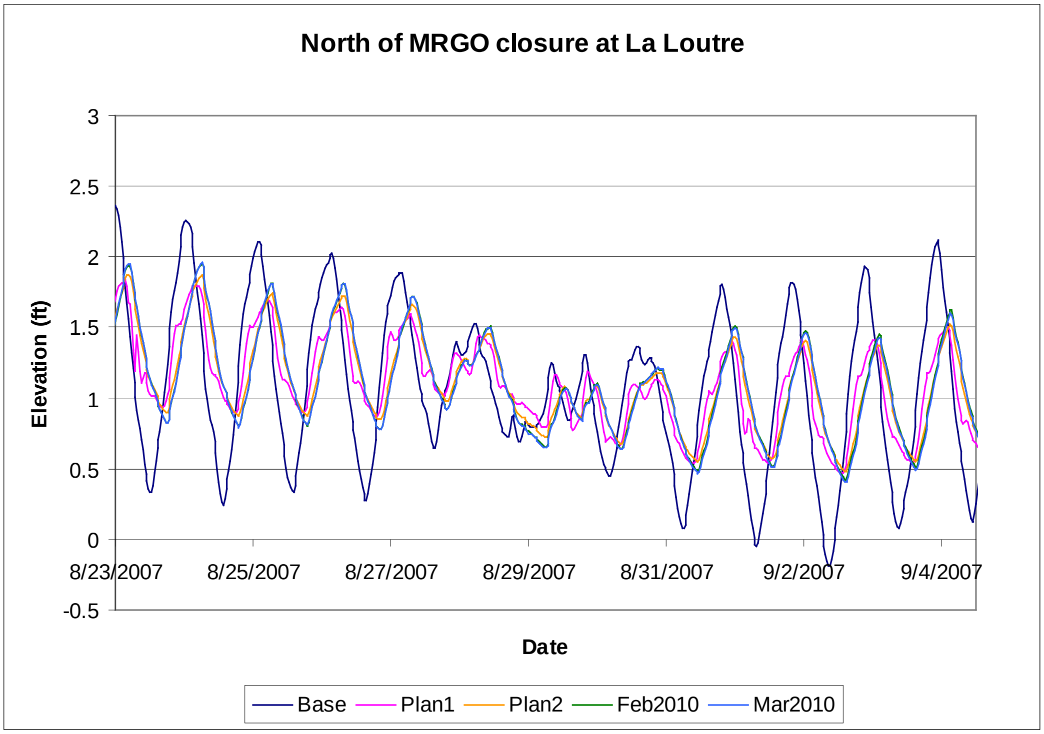


Figure 4-27. Water surface elevation north of MRGO closure at La Loutre (September).

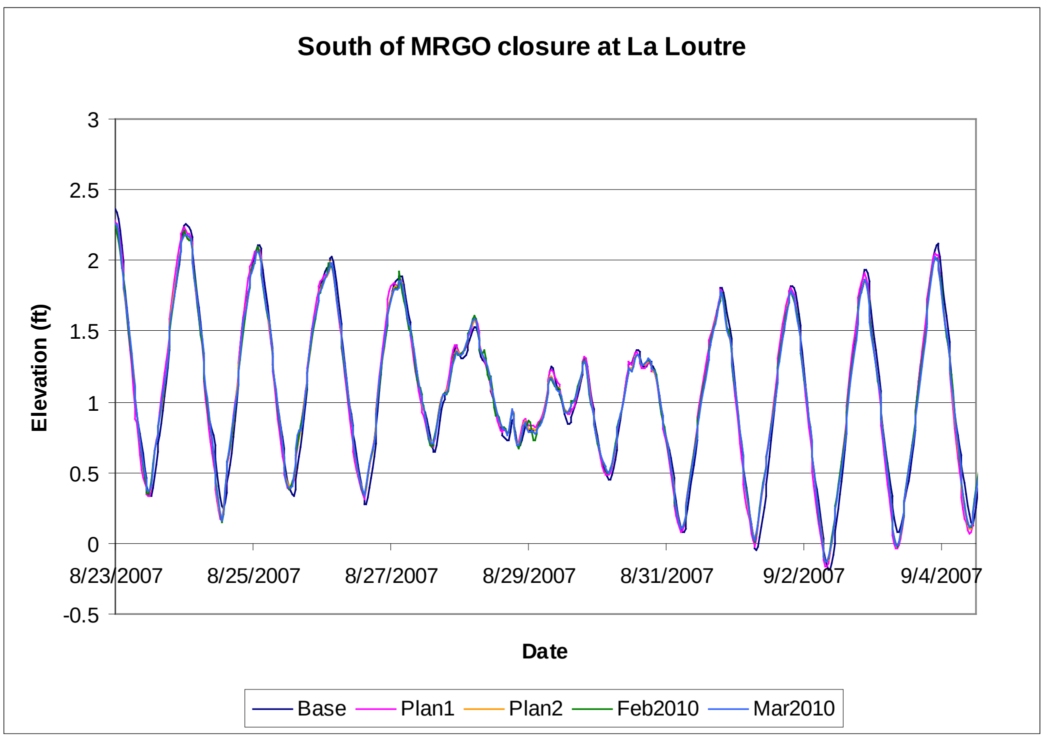


Figure 4-28. Water surface elevation south of MRGO closure at La Loutre (September).

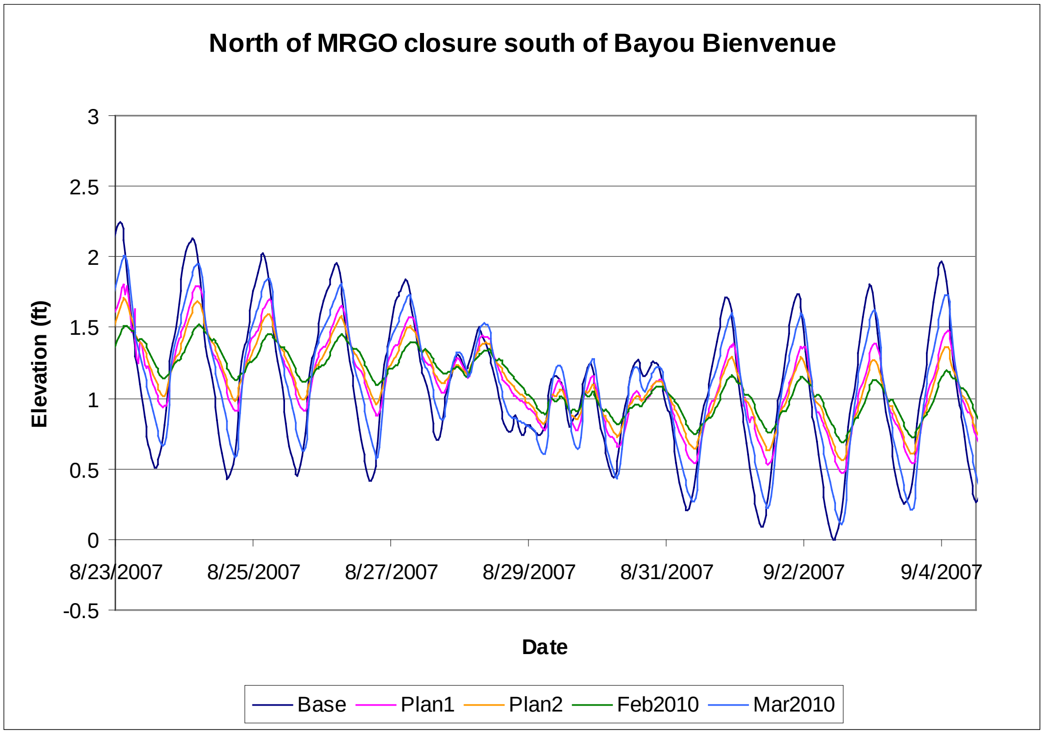


Figure 4-29. Water surface elevation north of MRGO closure at Bayou Bienvenue (September).

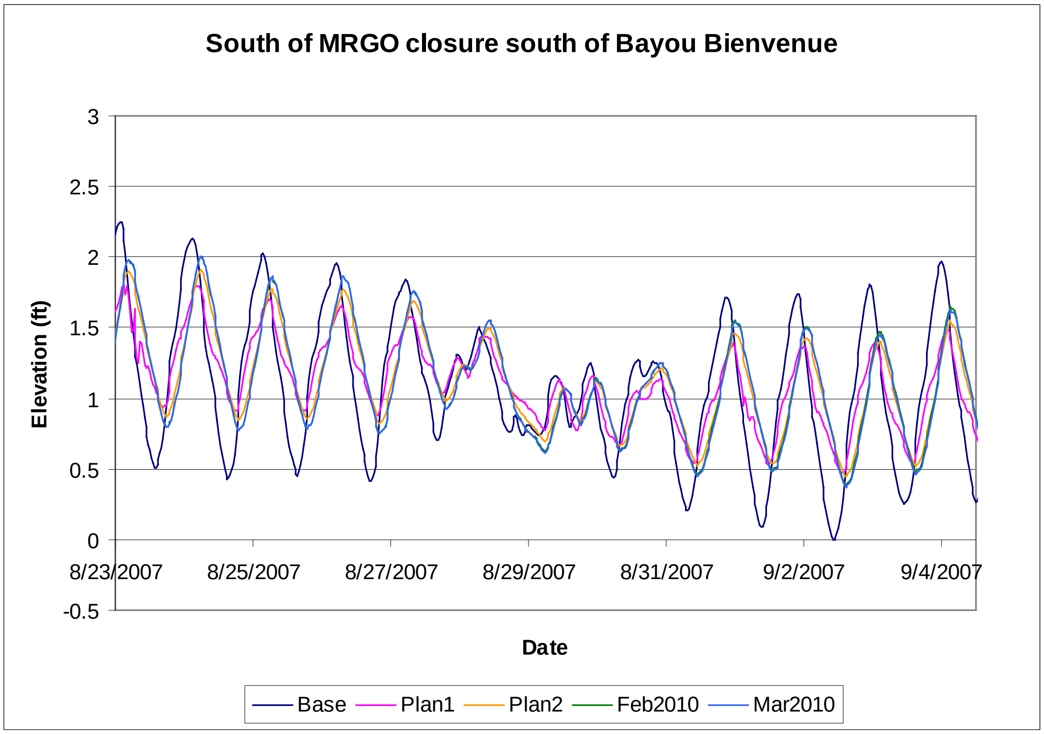


Figure 4-30. Water surface elevation south of MRGO closure at Bayou Bienvenue (September).

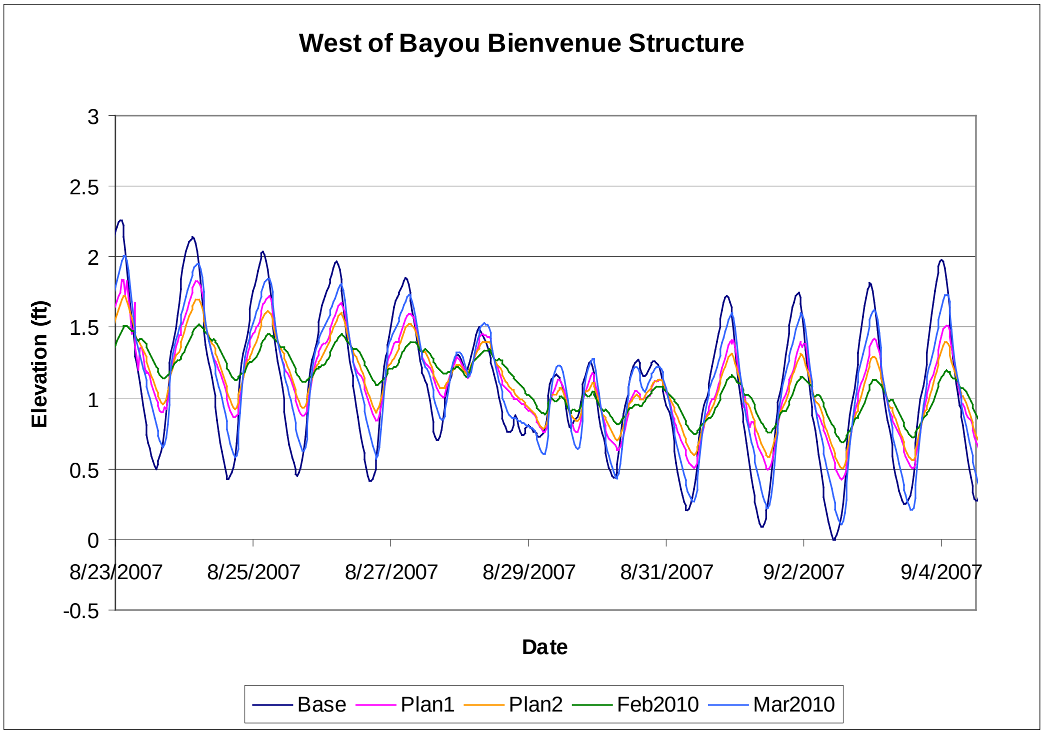


Figure 4-31. Water surface elevation west of Bayou Bienvenue structure (September).

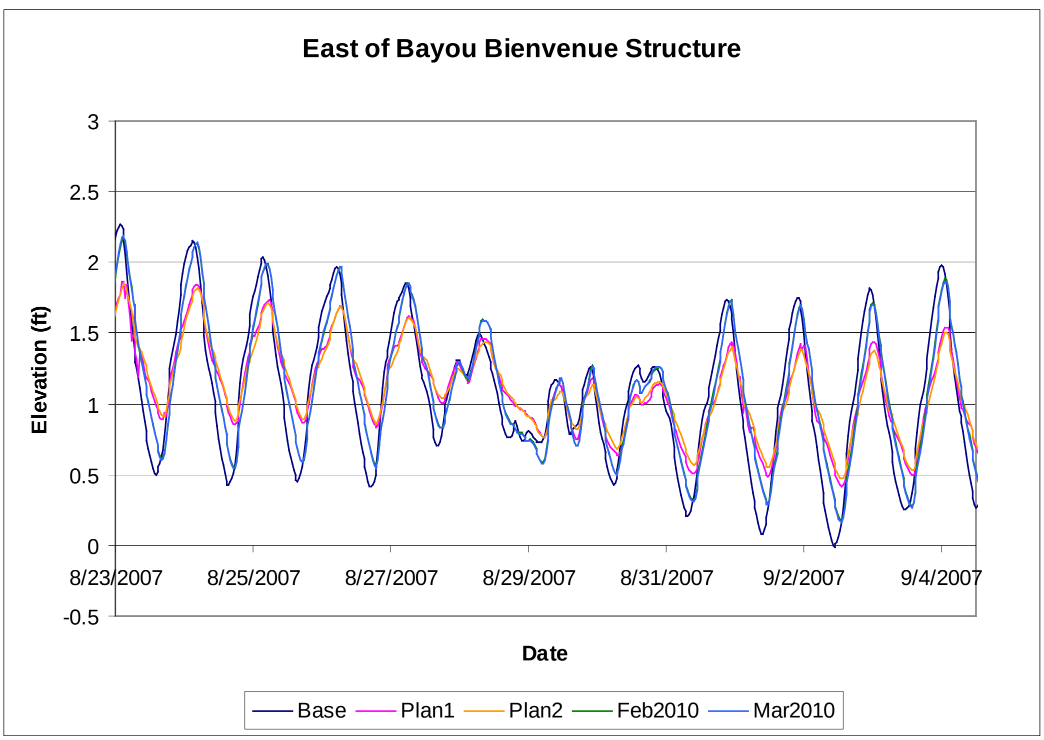


Figure 4-32. Water surface elevation east of Bayou Bienvenue structure (September).

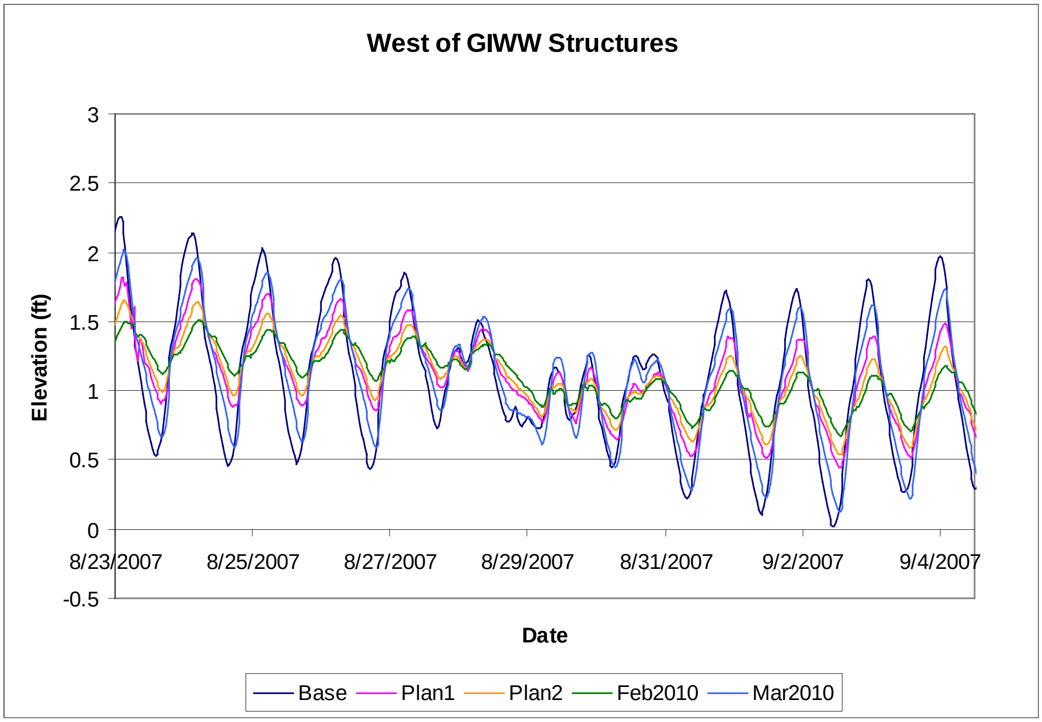


Figure 4-33. Water surface elevation west of GIWW structures (September).

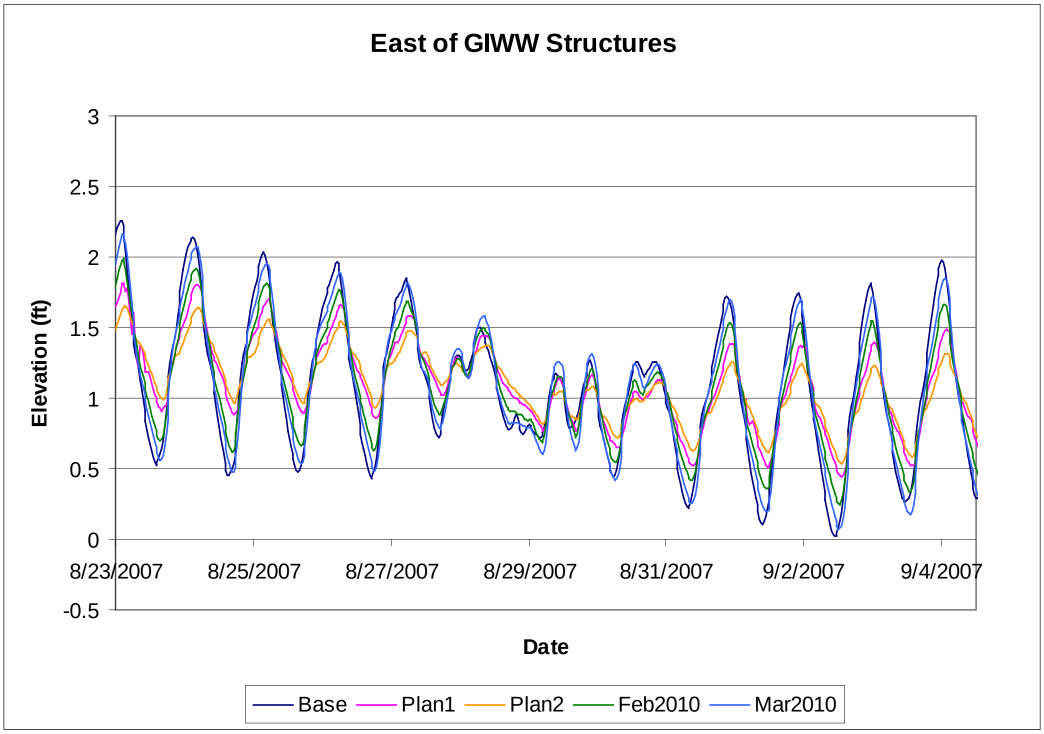


Figure 4-34. Water surface elevation east of GIWW structures (September).

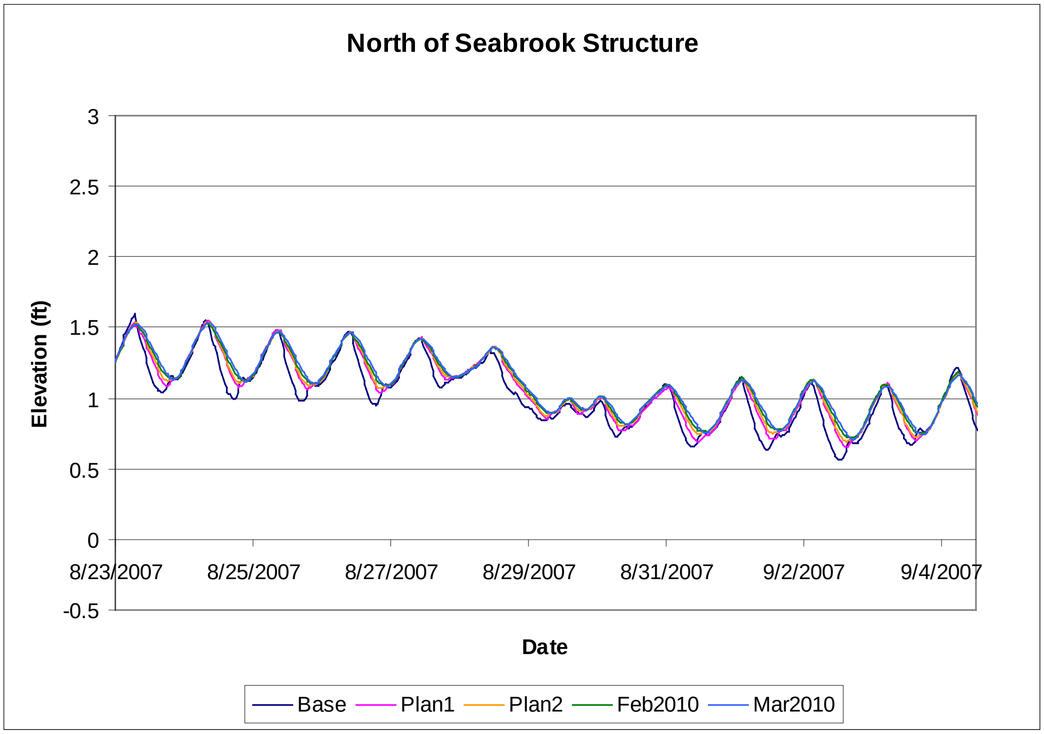


Figure 4-35. Water surface elevation north of Seabrook structure (September).

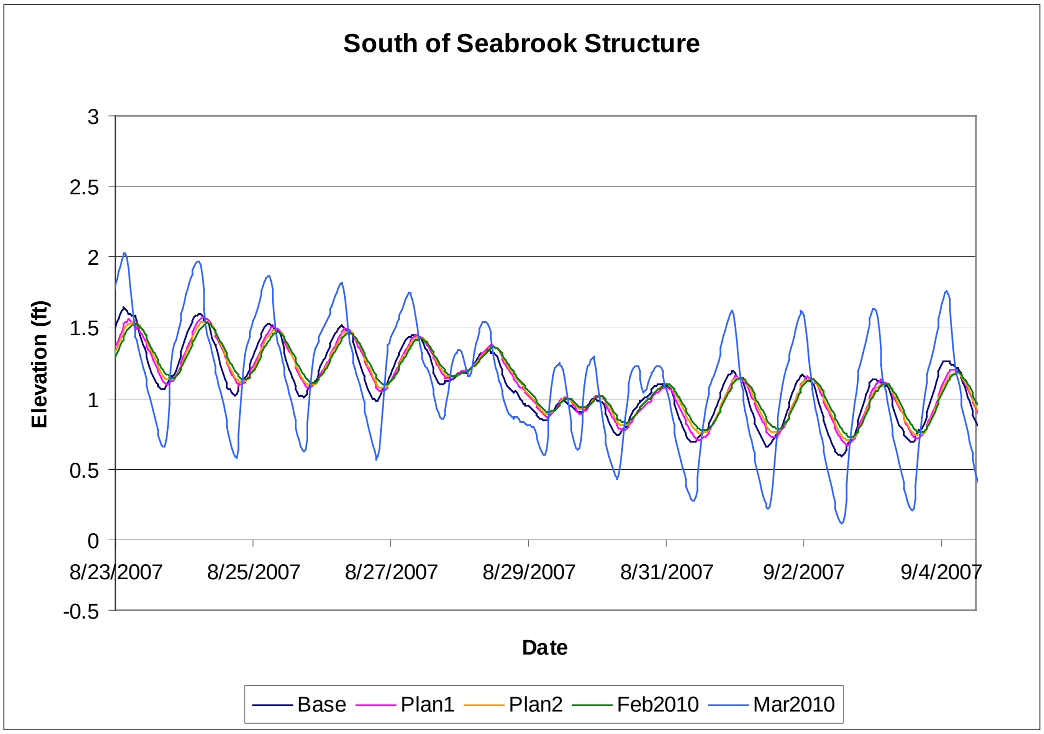


Figure 4-36. Water surface elevation south of Seabrook structure (September).

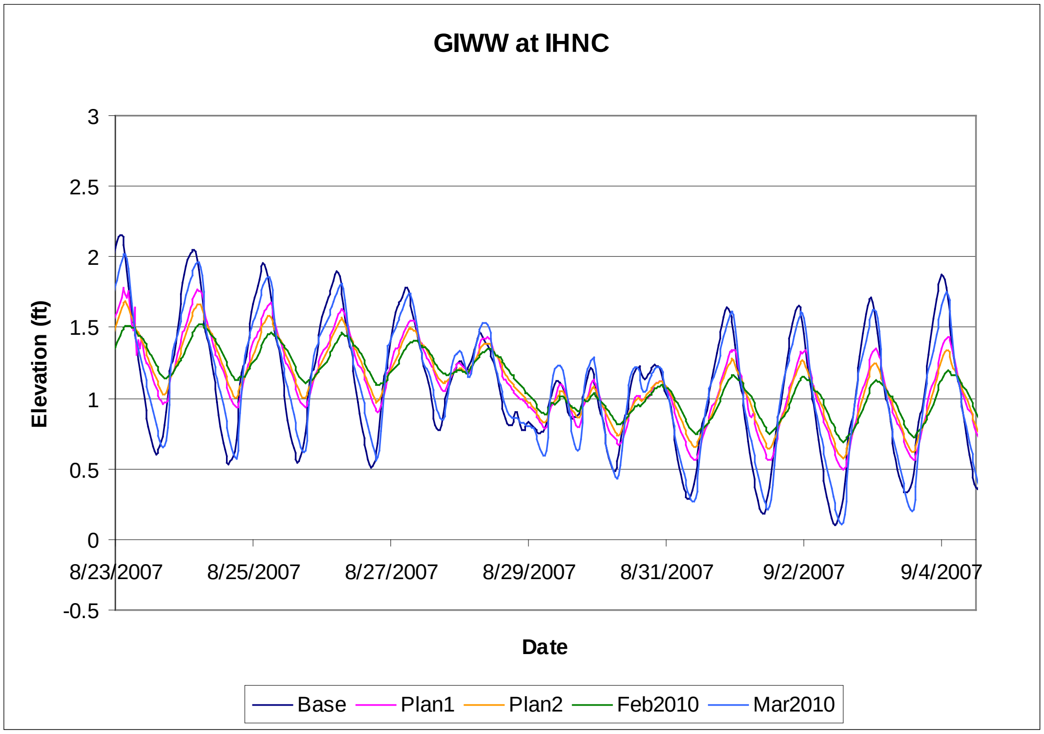


Figure 4-37. Water surface elevation in GIWW at IHNC (September).

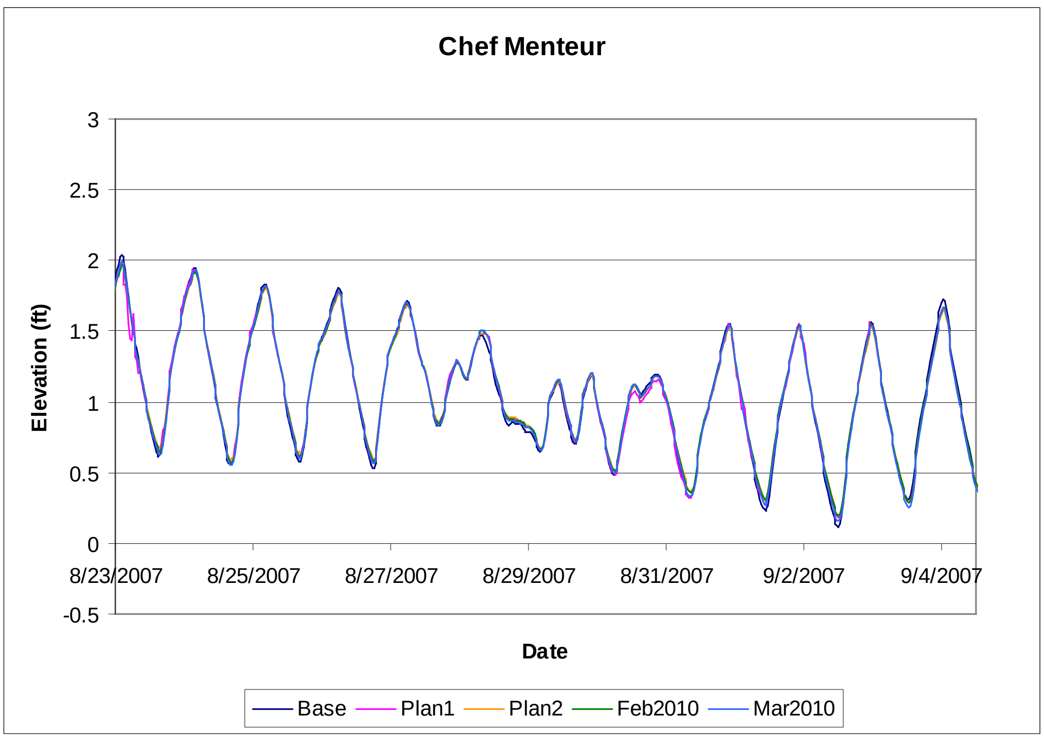


Figure 4-38. Water surface elevation in Chef Menteur (September).

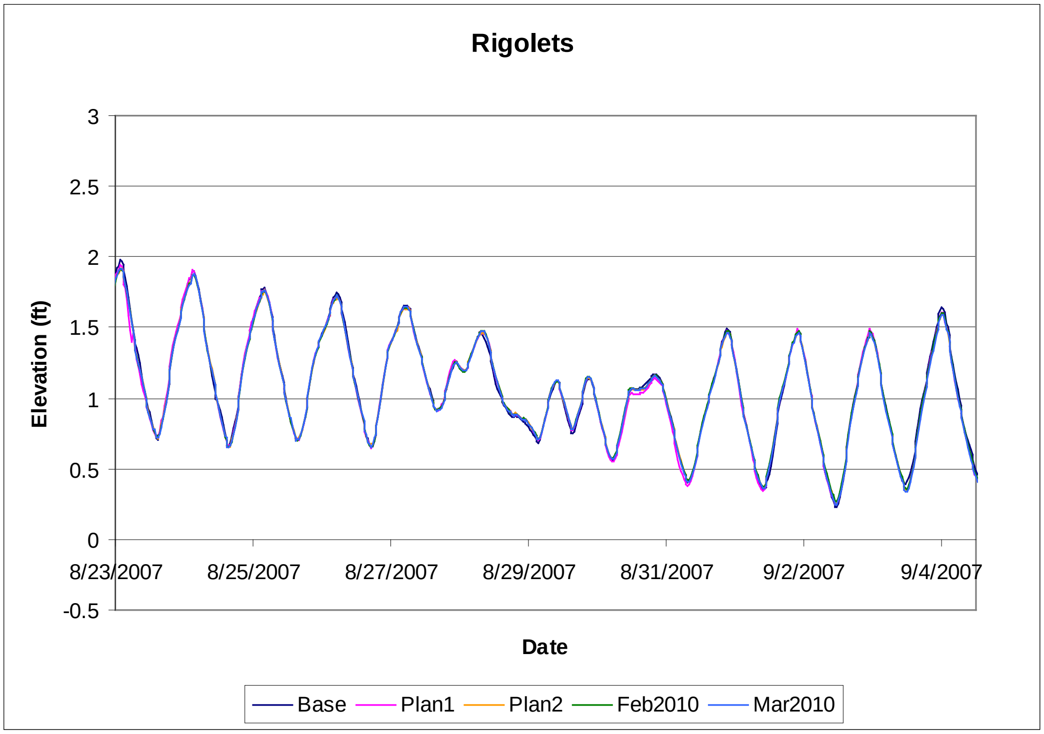


Figure 4-39. Water surface elevation north in Rigolets (September).

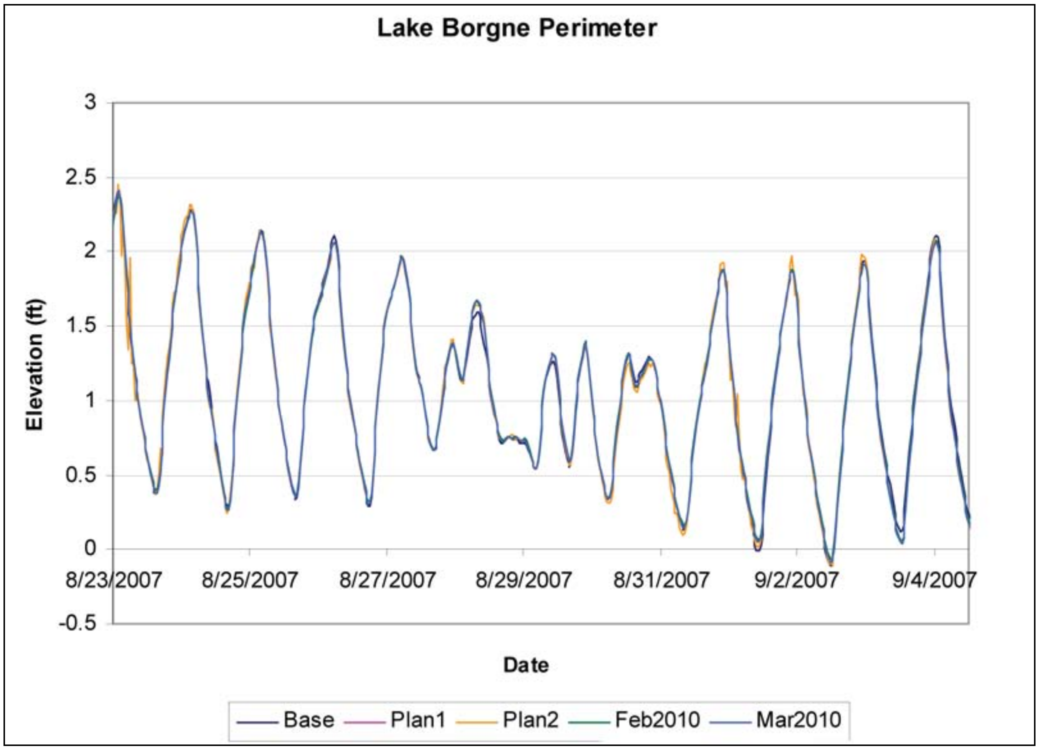


Figure 4-40. Water surface elevation at Lake Borgne perimeter (September).

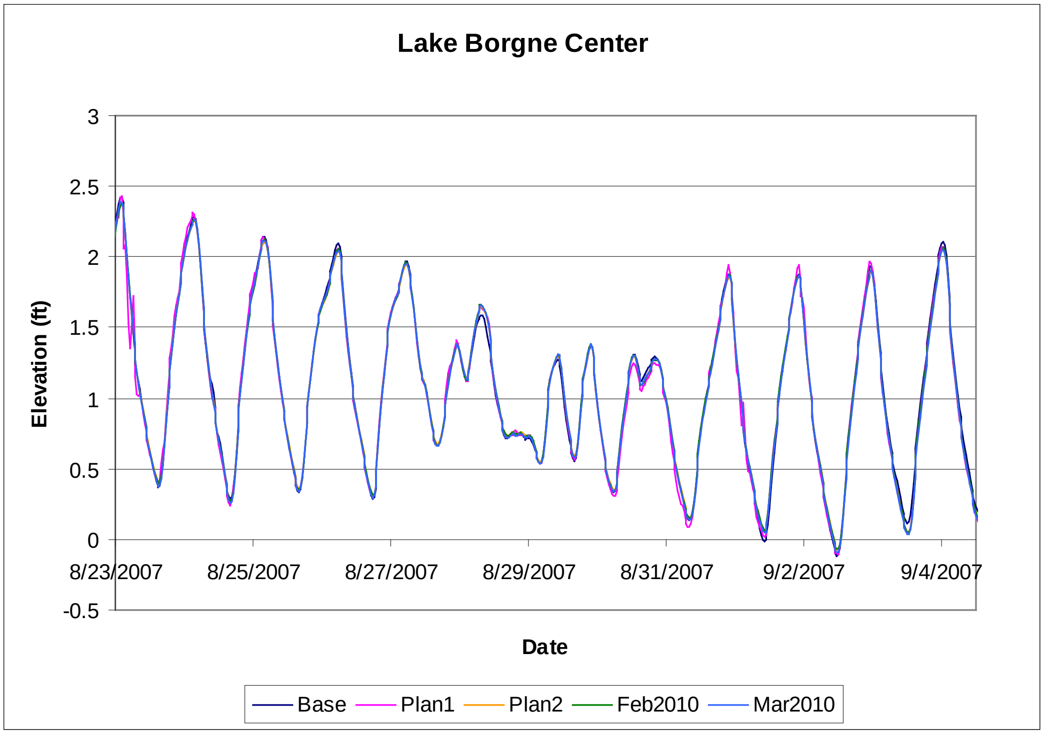


Figure 4-41. Water surface elevation at Lake Borgne center (September).

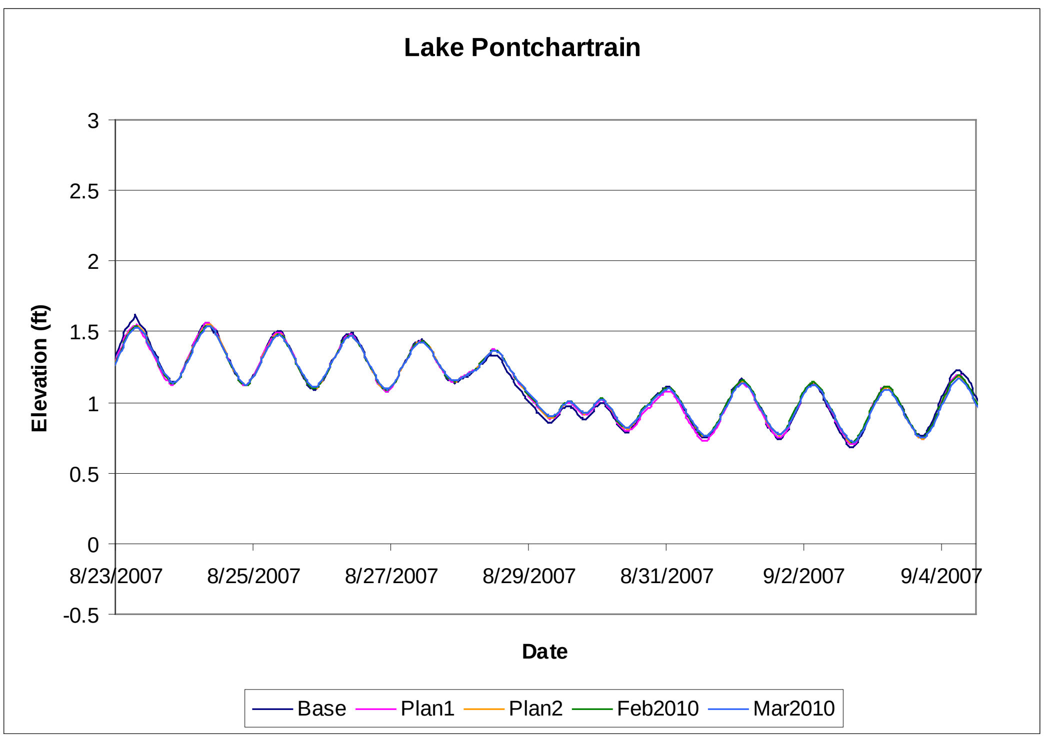


Figure 4-42. Water surface elevation at Lake Pontchartrain (September).

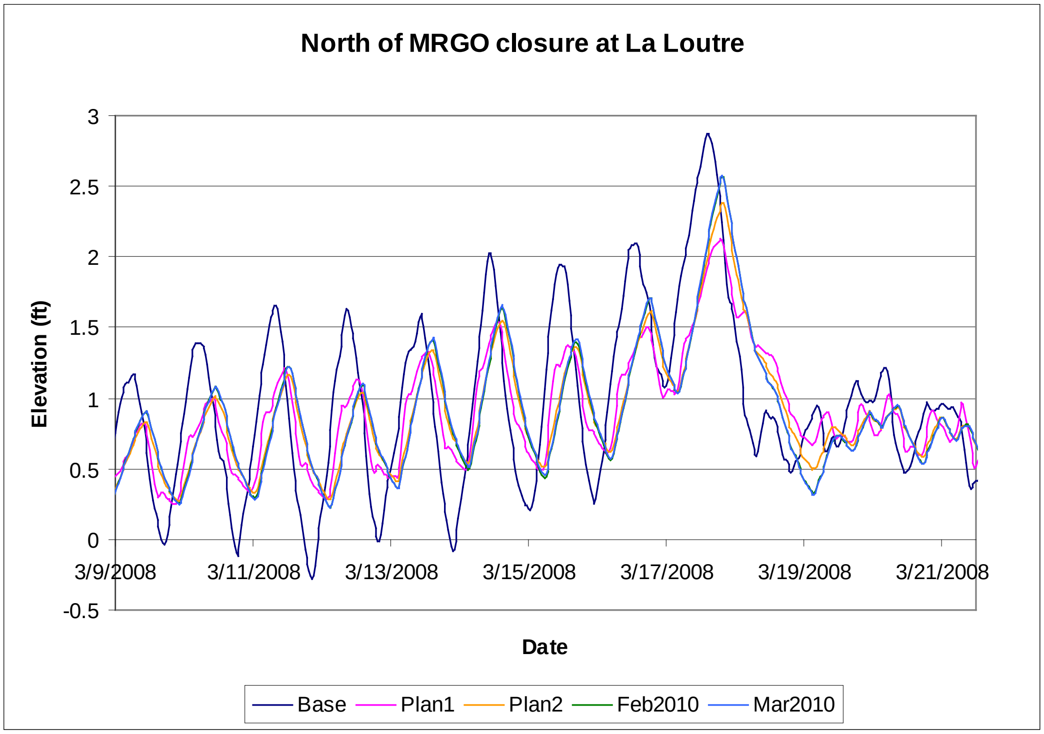


Figure 4-43. Water surface elevation north of MRGO closure at La Loutre (March).

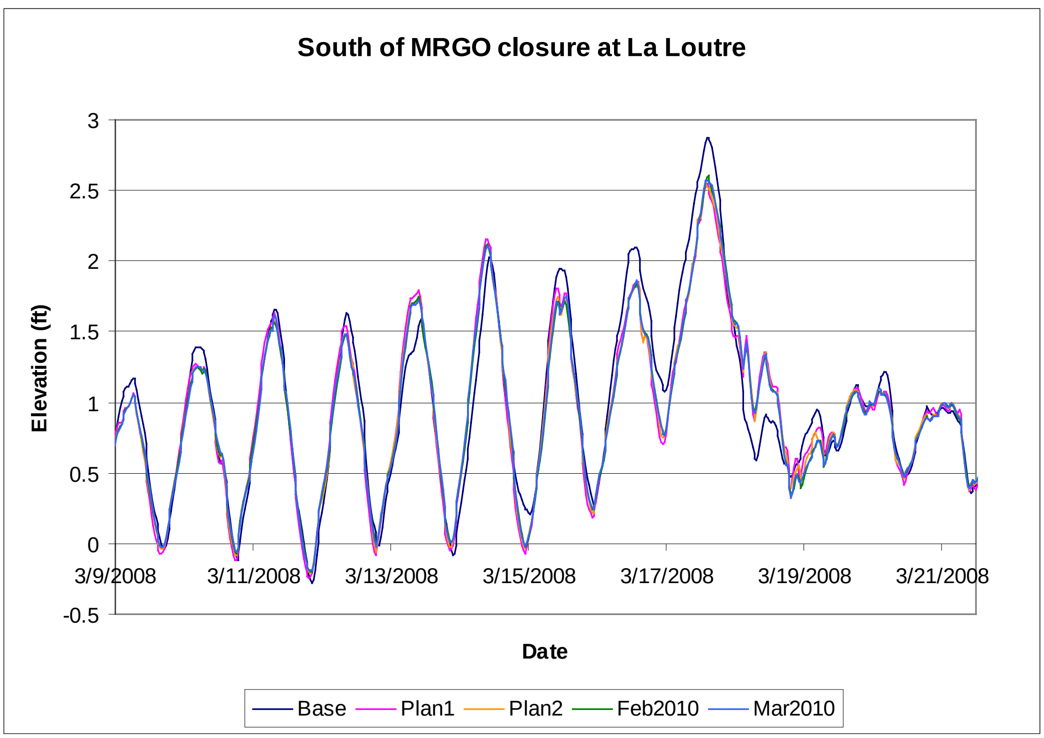


Figure 4-44. Water surface elevation south of MRGO closure at La Loutre (March).

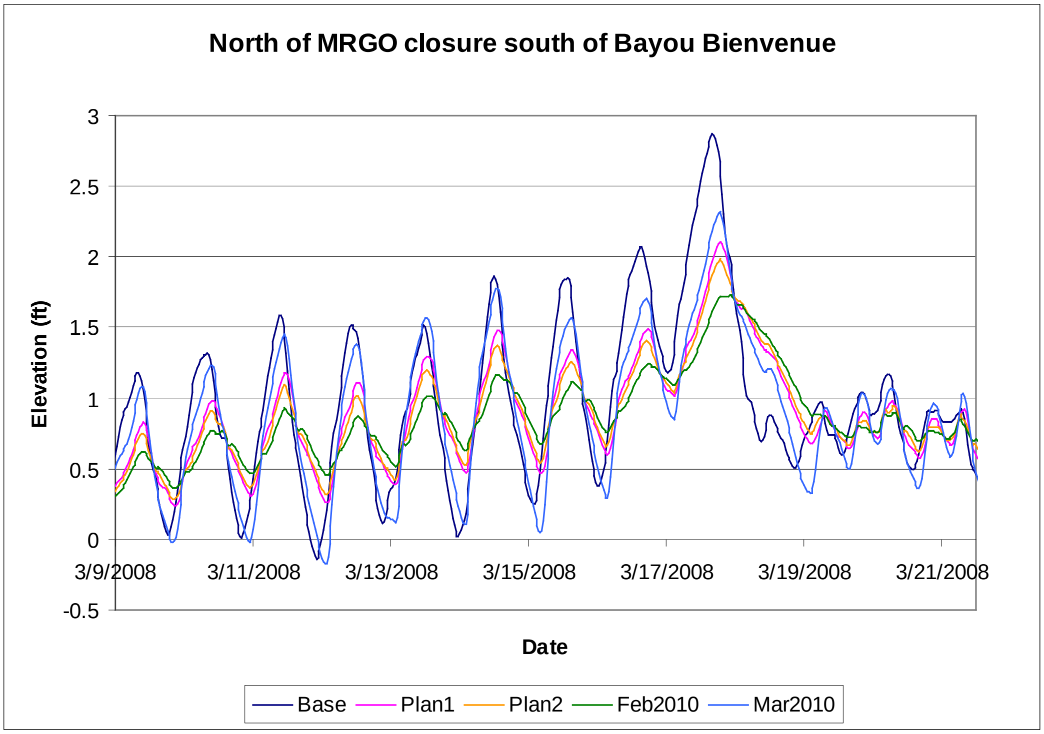


Figure 4-45. Water surface elevation north of MRGO closure at Bayou Bienvenue (March).

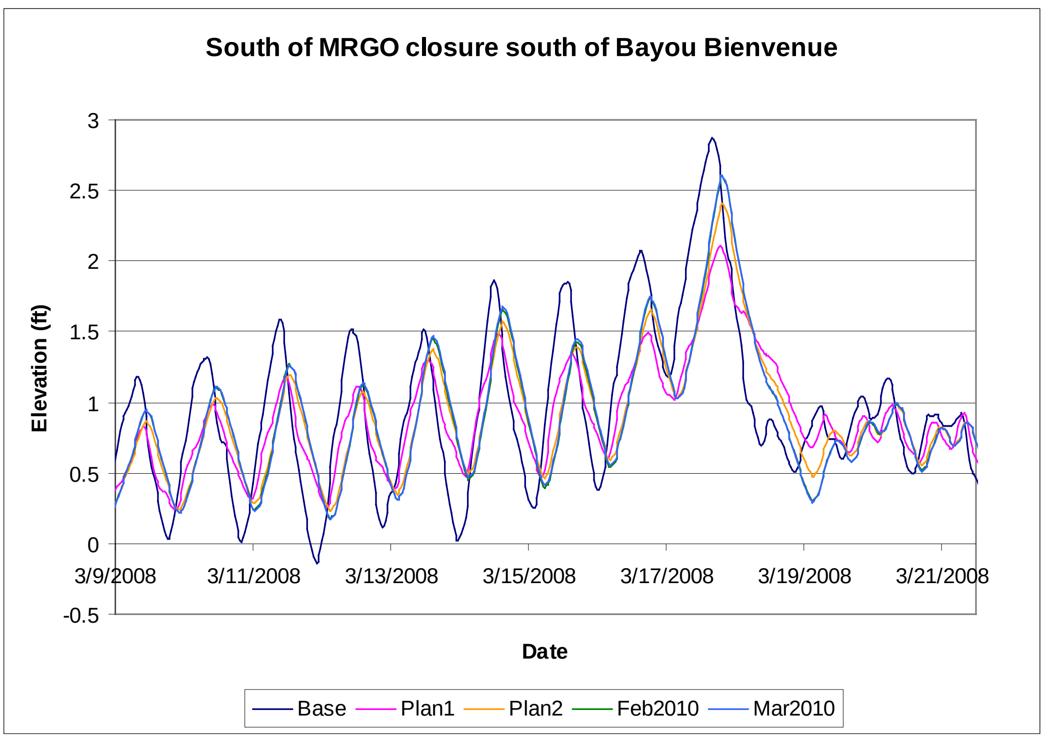


Figure 4-46. Water surface elevation south of MRGO closure at Bayou Bienvenue (March).

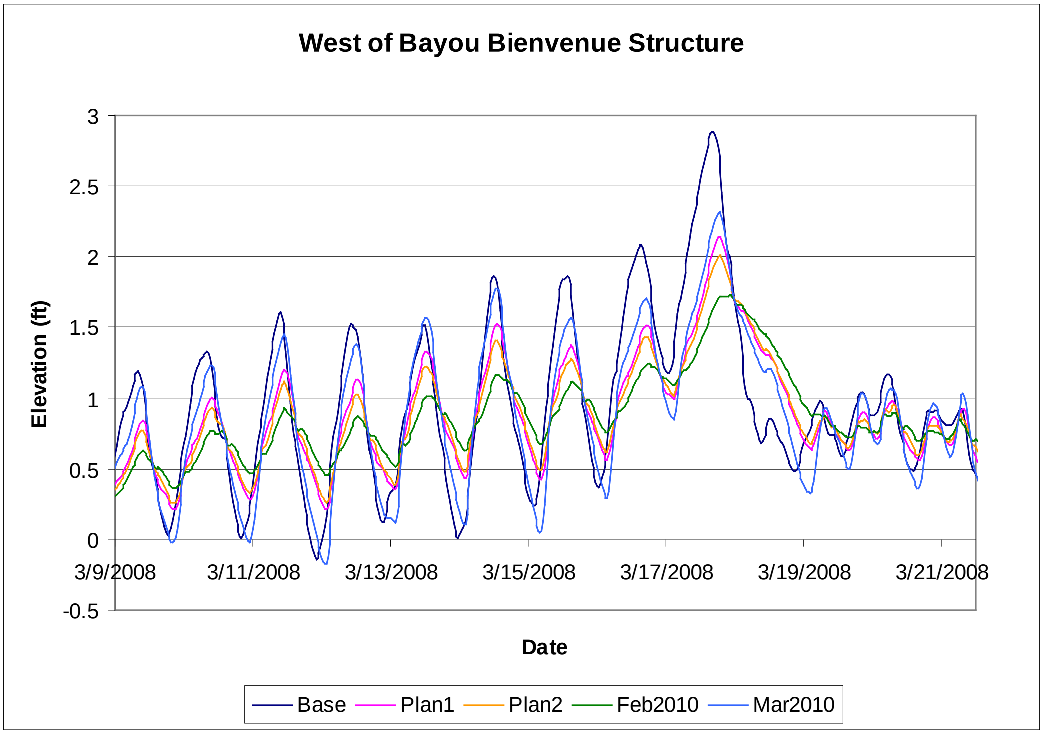


Figure 4-47. Water surface elevation west of Bayou Bienvenue structure (March).

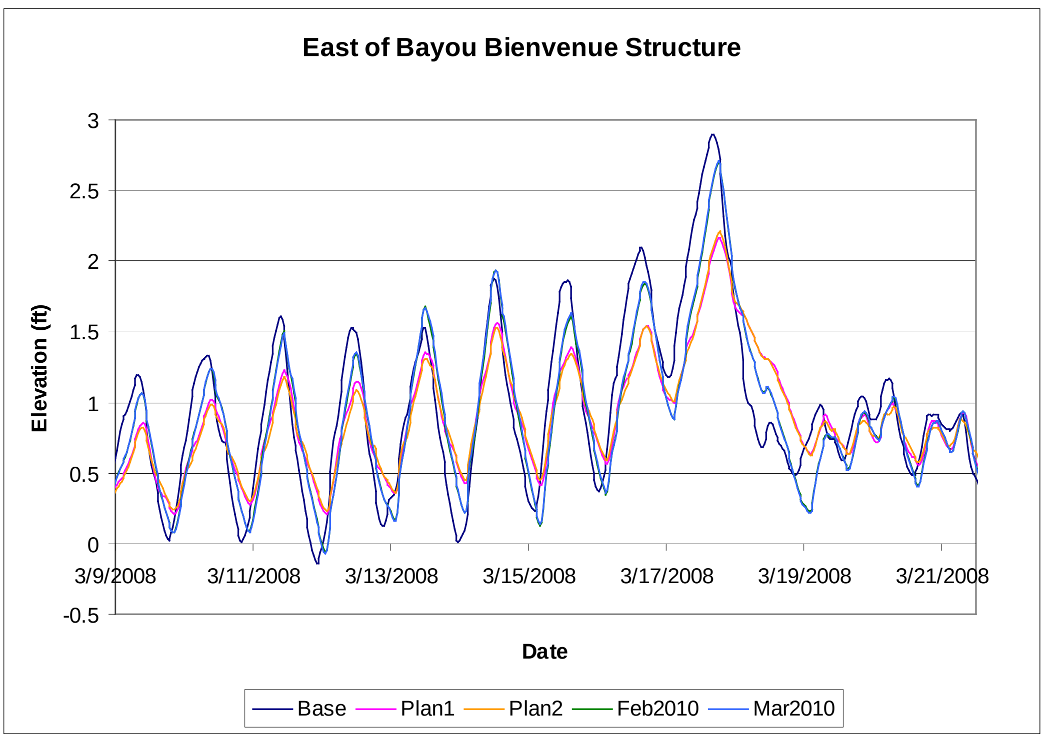


Figure 4-48. Water surface elevation east of Bayou Bienvenue structure (March).

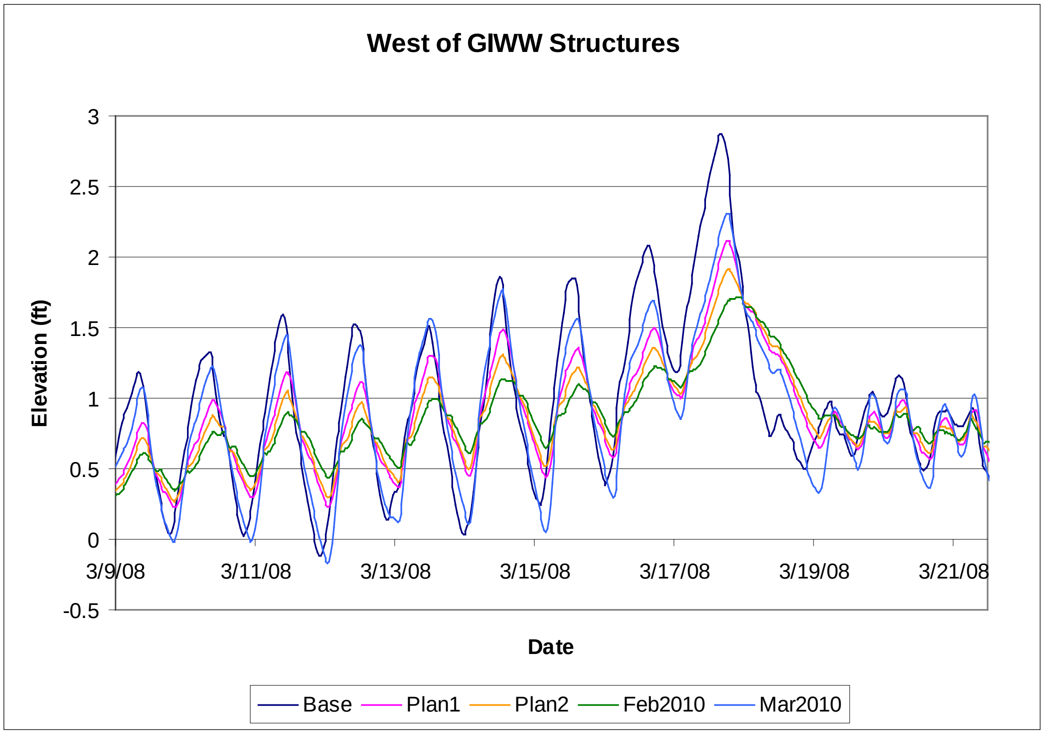


Figure 4-49. Water surface elevation west of GIWW structures (March).

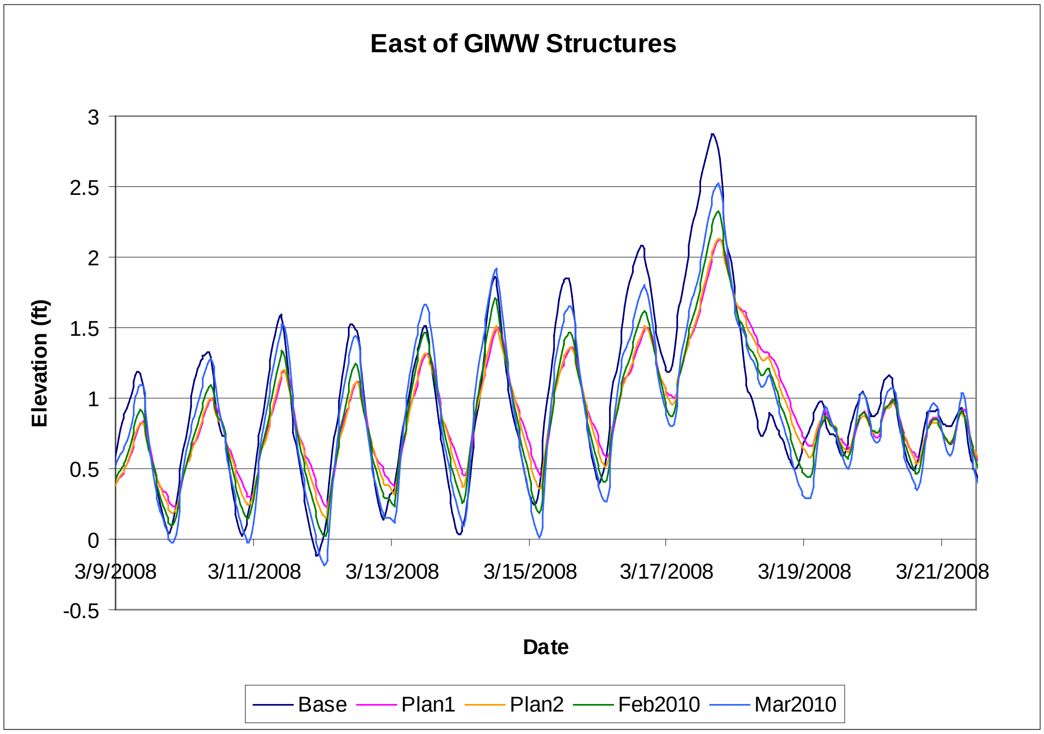


Figure 4-50. Water surface elevation east of GIWW structures (March).

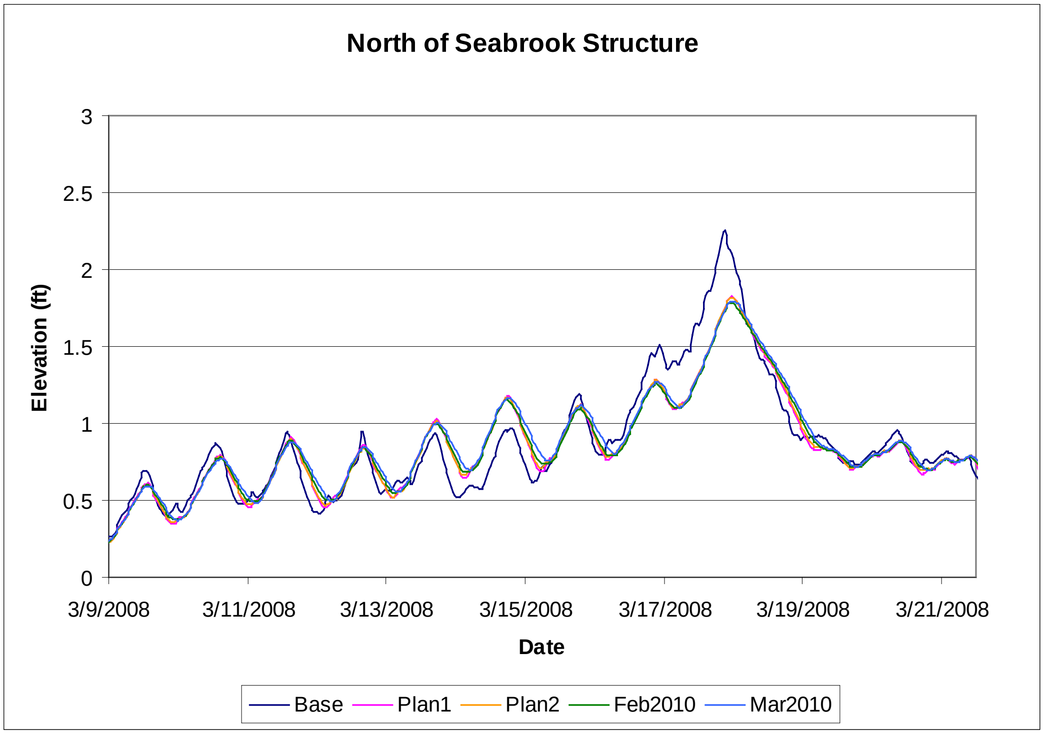


Figure 4-51. Water surface elevation north of Seabrook structure (March).

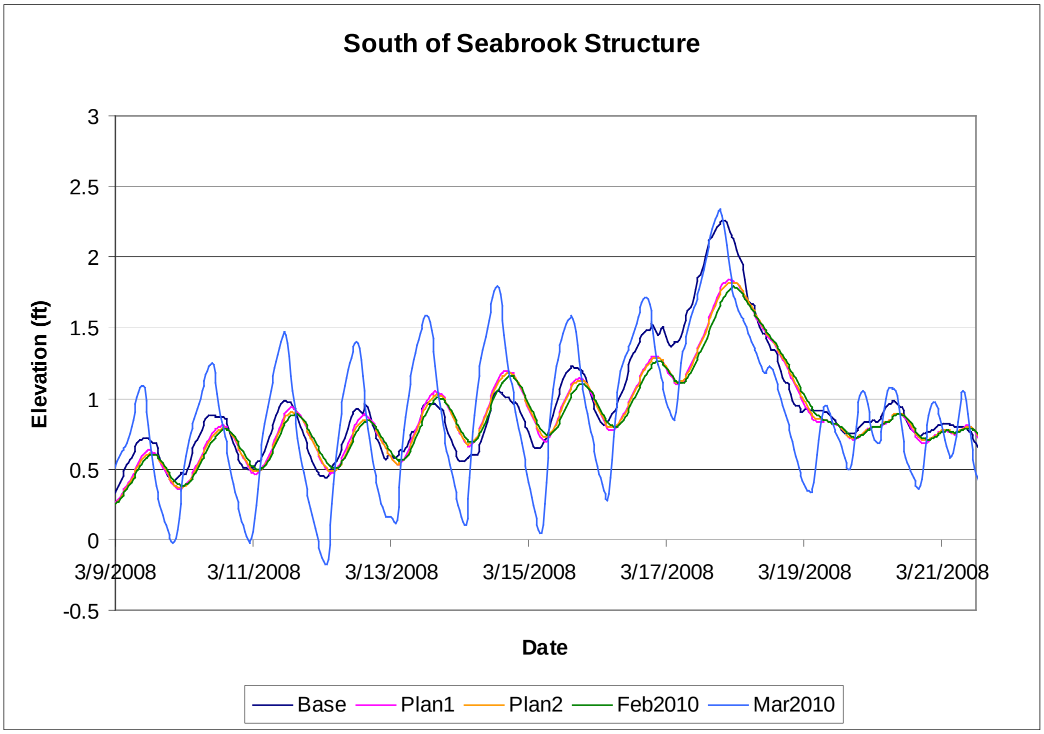


Figure 4-52. Water surface elevation south of MRGO Seabrook structure (March).

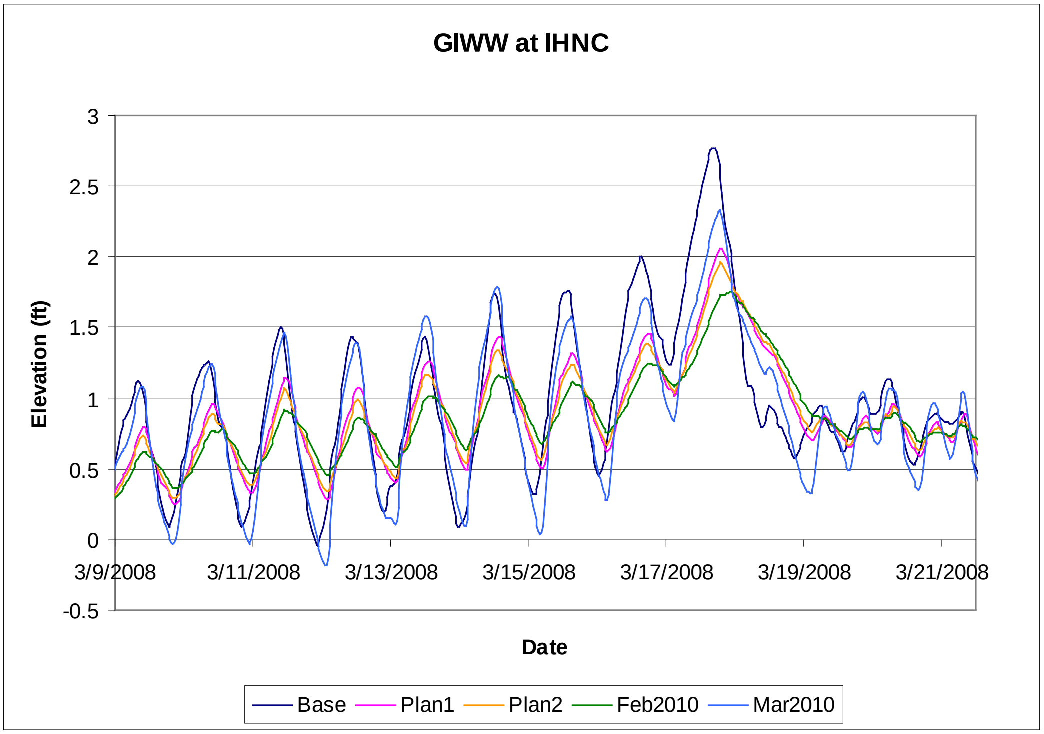


Figure 4-53. Water surface elevation in GIWW at IHNC (March).

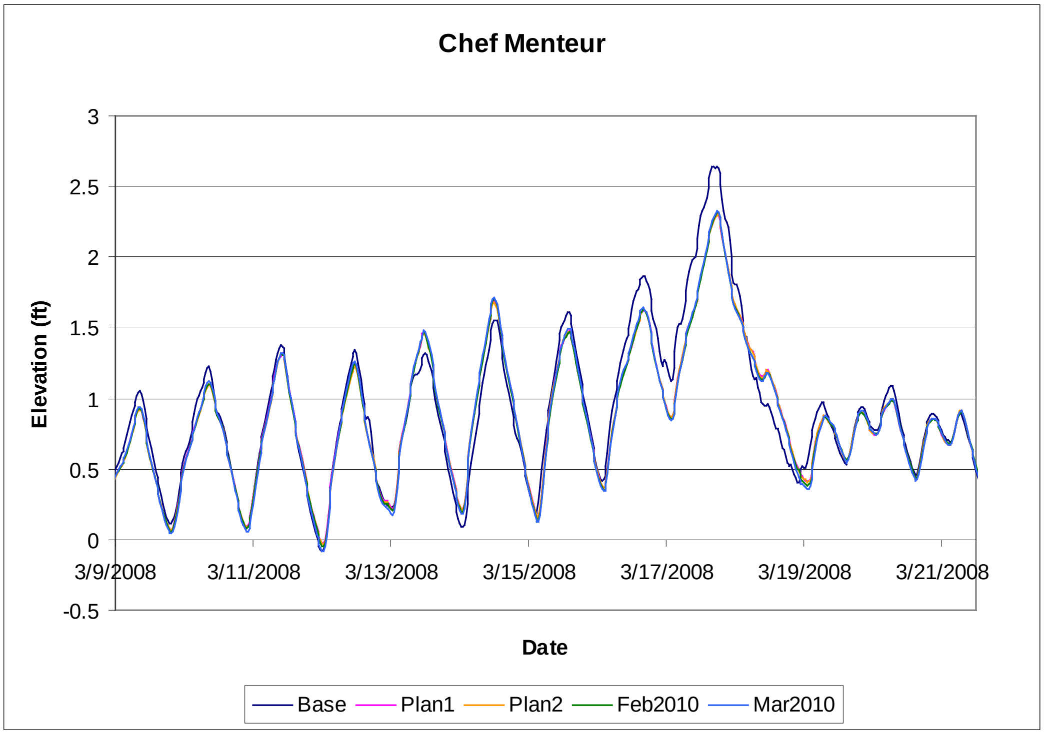


Figure 4-54. Water surface elevation in Chef Menteur (March).

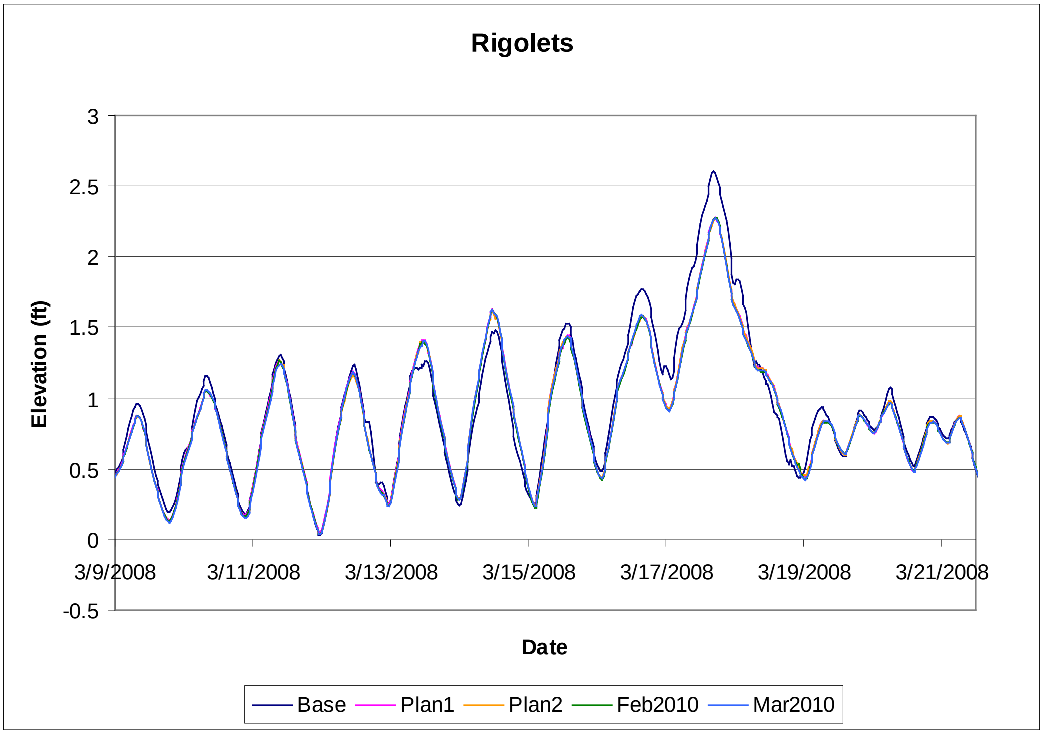


Figure 4-55. Water surface elevation in Rigolets (March).

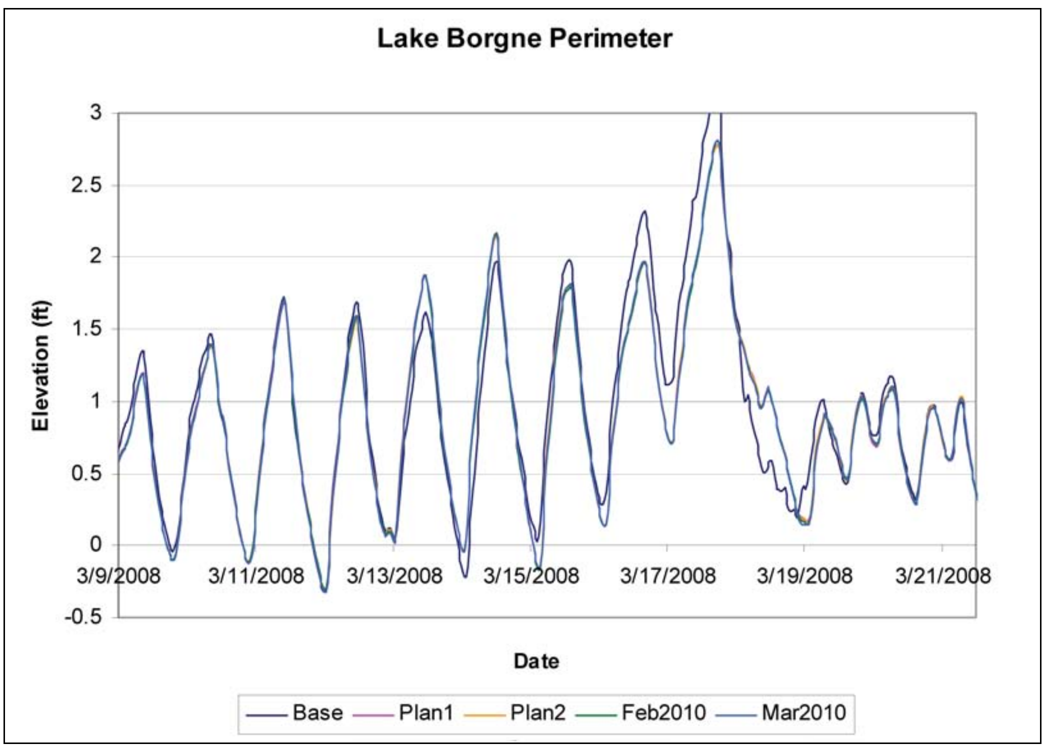


Figure 4-56. Water surface elevation at Lake Borgne perimeter (March).

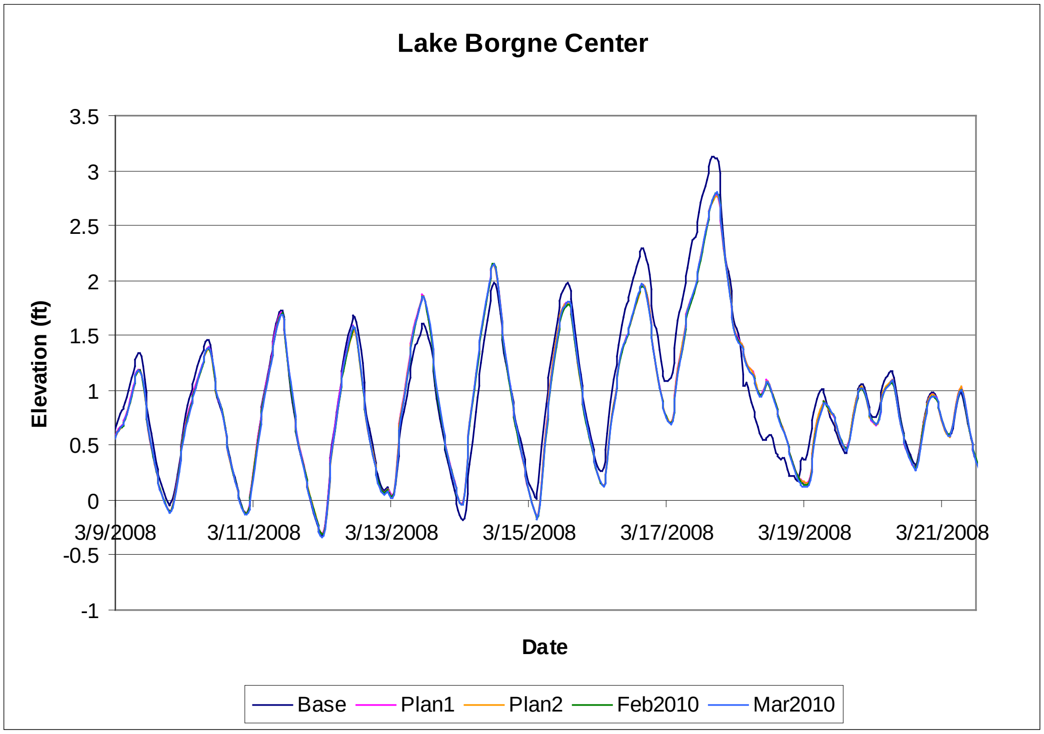


Figure 4-57. Water surface elevation at Lake Borgne center (March).

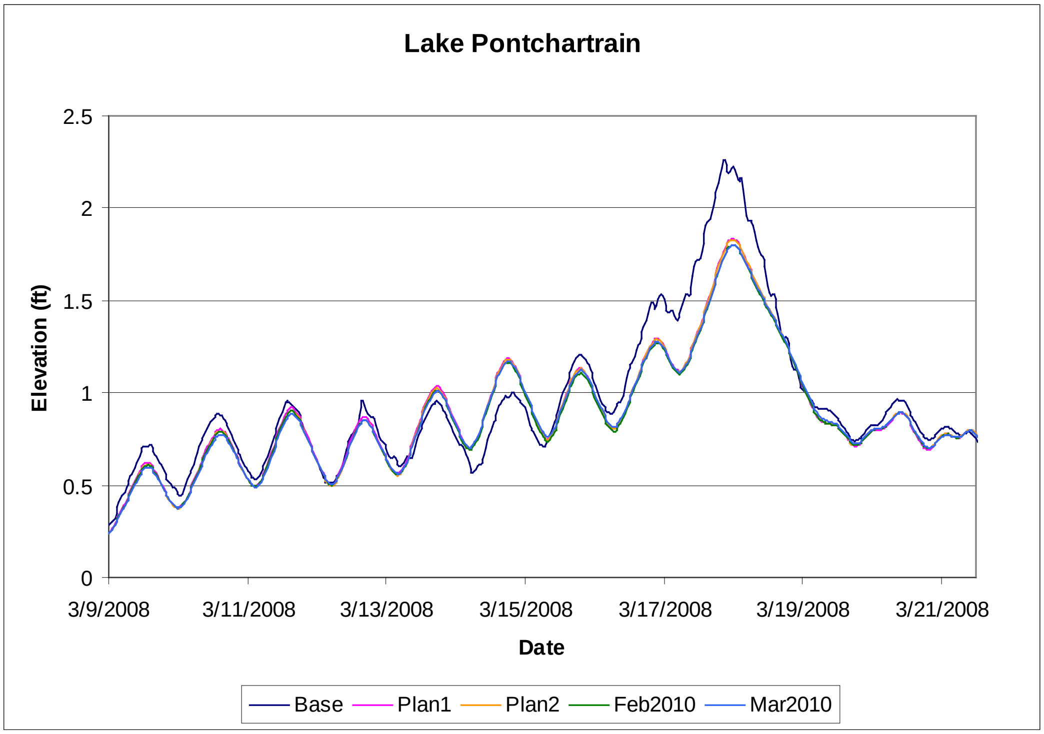


Figure 4-58. Water surface elevation in Lake Pontchartrain (March).

At the MRGO closure south of Bayou Bienvenue, the southern location is essentially the same as that for Plan 2 (Figure 4-30 and 4-46). At the northern location, however, the February 2010 plan shows a large drop in the range (Figures 4-29 and 4-45). Since there is a cofferdam at the Bayou Bienvenue structure in this plan, there is less flow into this area. Also, the flow through the GIWW is allowed to exit the area at Seabrook under this plan. The March 2010 plan shows very different results given that a cofferdam is in place at Seabrook. With this plan there is no flow through Seabrook, so all of the flow exchange through the GIWW is getting forced into a limited space, generating an increased range of water surface on the west side of Bayou Bienvenue (Figures 4-31 and 4-47).

On the western side of the cofferdam at the Bayou Bienvenue structure, the February 2010 plan again indicates a reduction in water level range while the March 2010 plan shows an increase. On the eastern side of this structure (Figures 4-32 and 4-48) the results are similar in character for both construction sequence plans. Since this structure has a cofferdam for both and the effects of the plans do not extend into Lake Borgne, this similarity is a logical result. At this location, these plans generate an increase in range from the Plan 1 and Plan2 conditions, yet the range is still less than that for the Base condition.

The western side of the GIWW structures (Figures 4-33 and 4-49) shows similar results to those on the west side of the Bayou Bienvenue structure, although in this case only part of the channel is closed. By having a cofferdam at Seabrook (March 2010), the water surface elevation increases between Seabrook and the GIWW structures due to Lake Pontchartrain no longer have an effect on the water surface elevations at this location and the only path of flow is through the GIWW barge gate. On the eastern side of the GIWW structures (Figures 4-34 and 4-50), both plans produce an increase in the water surface elevation range. The values for the March 2010 plan are greater than those for the February 2010 plan, although the March 2010 values do not exceed those from the original Base condition.

The effects of these construction sequence plans at the Seabrook locations are such that the location north of the structure (Figures 4-35 and 4-51) experiences little change. This is due to the large area at this location in the Lake. There is a small reduction in the low end water level values, but this change is small. South of the structure (Figures 4-36 and 4-52), however, there is a large increase in the water level when the pathway is

closed. The March 2010 plan indicates amplifications of the flows reaching this location on the order of 50%. Seabrook was the only outlet for the wave traveling the GIWW, so now that this pathway is blocked, the tide is stopped at this location. The February 2010 plan does not experience this effect since the flow entering the GIWW can still pass through Seabrook. For this plan, there is actually a slight drop in water surface at the southern Seabrook location.

One analysis location lies between the GIWW structures and Seabrook. At this location where the GIWW meets the IHNC, the same general pattern is evident (Figures 4-37 and 4-53). The February 2010 plan generates a decrease in the water surface elevation range and the March 2010 plan generates an increase. There is a slight shift in phase for the March 2010 condition as well due to the complete blockage at Seabrook. The drop in range for February 2010 is due to the limitation of the flow volume through the GIWW barge gate.

Circulation Changes

For all of these analyses, the driving factor is the pathway through which flow is allowed. The February 2010 plan only allows flow from Lake Borgne to pass through the 150 ft wide GIWW barge gate and then into Lake Pontchartrain at Seabrook. No flow is able to travel up the MRGO or into the area through Bayou Bienvenue since both pathways are blocked. The March 2010 plan further limits the transport pathways by allowing flow exchange through the GIWW barge gate with no exit at Seabrook. The only means for exchange into Lake Pontchartrain is through Chef Menteur and the Rigolets. Therefore all flow entering the GIWW and IHNC is limited to exiting the system in the same manner, through a single 150 ft structure. Figures 4-59 and 4-60 illustrate the circulation patterns. The yellow lines indicate locations where the pathways are blocked due to construction.

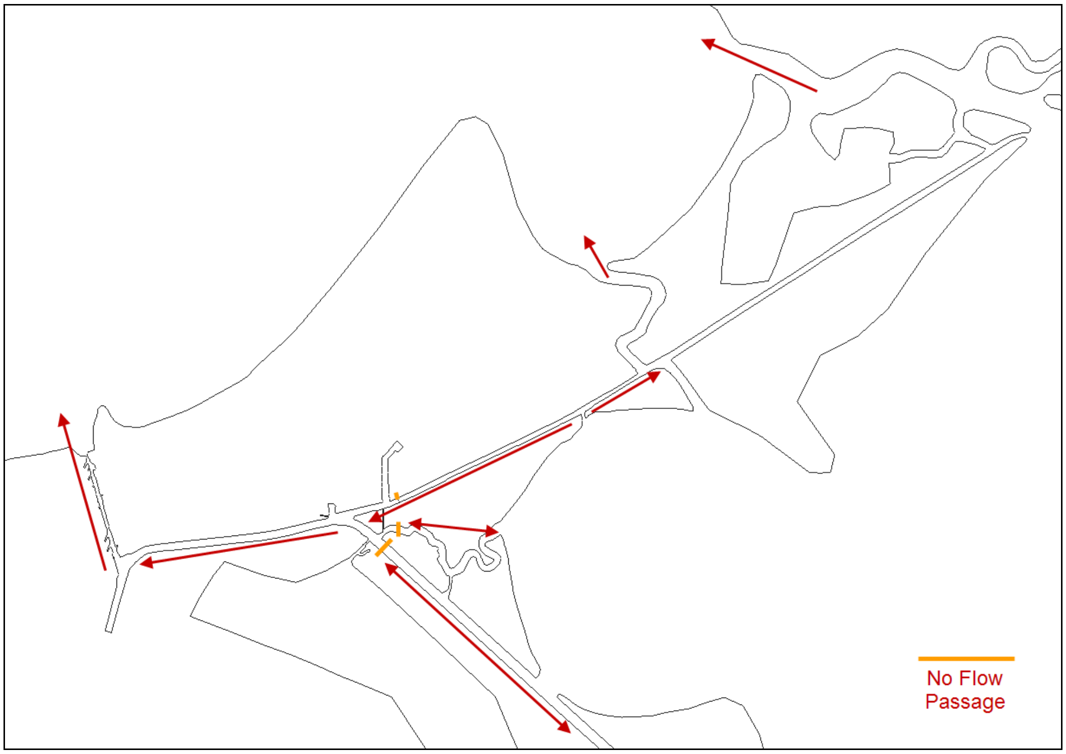


Figure 4-59. February 2010 plan circulation.

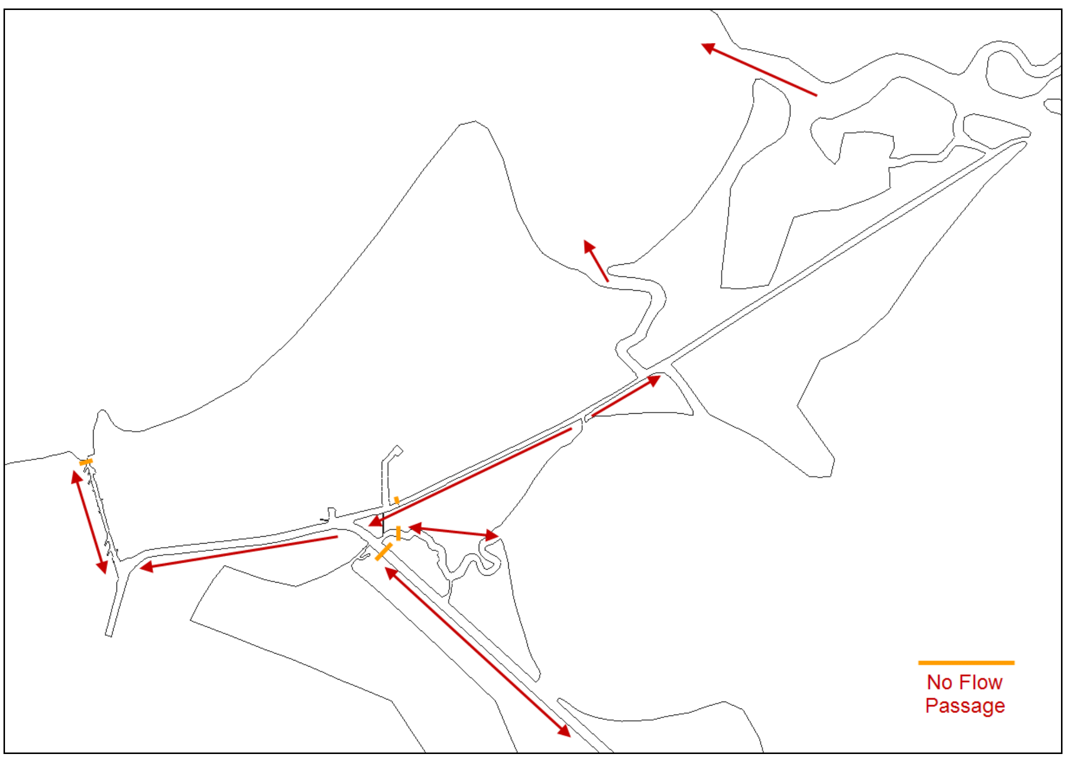


Figure 4-60. March 2010 plan circulation.

5 Conclusions

The work presented in this report documents hydrodynamic modeling and analysis of two construction sequence plans which will occur during the construction of the Borgne alignment and Seabrook structures included in the HSDRRS. This plan will allow for improved protection of the city of New Orleans, Louisiana, as well as surrounding areas. Previous research focused on the changes that these structures would generate on the flows and fish transport. Research is also being performed to analyze the effects these changes have on navigation. This report specifically focuses on the construction sequence plans during which the Bayou Bienvenue structure and GIWW sector gate are being built as well as the construction of the Seabrook structure. The February 2010 plan includes cofferdams on the Bayou Bienvenue and at the GIWW sector gate in addition to closing the MRGO at La Loutre and south of Bayou Bienvenue. The March 2010 plan adds a cofferdam at Seabrook.

Water surface elevation, velocity magnitude and direction, and percent less than analyses were performed at several locations within the model domain, focusing on the areas likely to be affected by the plan changes. The average velocity values are given in Table 1. The results of the model simulations indicate that these construction sequence plans generate changes to water surface elevations and velocity magnitudes and flow patterns in the vicinity of the system changes. These plans do not generate measurable changes in Lake Pontchartrain or Lake Borgne.

Table 1. Average velocity values at the GIWW and Seabrook structures for the base and each construction sequence plan during both analysis periods

Average Velocity (ft/s)	Base				Feb 2010				Mar 2010			
	Positive		Negative		Positive		Negative		Positive		Negative	
	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar
GIWW	0.2	0.2	-0.2	-0.1	2.9	3.0	-2.8	-3.1	1.8	1.5	-1.7	-1.6
Seabrook	2.4	2.7	-2.4	-2.6	0.9	1.1	-0.9	-1.1	0.0	0.0	0.0	0.0

At the GIWW barge gate, the February 2010 changes to velocity are much larger than the March changes and may impact navigation through this structure. At Seabrook, the February 2010 plan decreases the velocity

magnitudes since less flow is entering the system due to the constriction on the GIWW.

Water surface elevations are effected in a different manner. The February 2010 plan reduces the water surface elevation range at most locations when compared to the plan condition that includes the Borgne alignment (Plan 2). However, the March 2010 plan increases the water surface elevation ranges in the locations confined by the closures. By limiting the pathways by which the tidal range can travel, flow is limited and can get trapped and amplified within the system. The magnitude of these changes should be considered when determining the operating procedures during the planned construction sequence.

References

McAnally, W. H., and R. C. Berger. 1997. *Salinity Changes in Pontchartrain Basin Estuary Resulting from Bonnet Carre` Freshwater Diversion*. Technical Report CHL-97-2. Vicksburg, MS: U.S. Army Waterways Experiment Station.

Tate, J. N., A. R. Carrillo, R. C. Berger, and B. J. Thibodeaux. 2002. *Salinity Changes in Pontchartrain Basin Estuary, Louisiana, Resulting from Mississippi River-Gulf Outlet Partial Closure Plans with Width Reduction*. CHL-TR-02-12. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Tate, Jennifer N., T. C. Lackey, and T. O. McAlpin. 2010. *Seabrook Fish Larval Transport Study*. Technical Report in review. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Appendix A: Half Cofferdam at Seabrook

After initial analysis of the construction sequence plans, February 2010 and March 2010, HPO requested that a simulation be performed in which the cofferdam at Seabrook only blocks the western half of the waterway. The scour hole to the south of the structure location will be filled and flow will be allowed to pass through the eastern side of the IHNC at Seabrook. The cofferdams at the GIWW sector gate and Bayou Bienvenue gates are still in place and the two MRGO closures have been included. Figure A1 shows this configuration at Seabrook. The same analysis periods will be simulated for this configuration as used previously, August 15 – September 15, 2007 and March 1 – 31, 2008. For this configuration, however, only a limited selection of locations will be analyzed for effects on water surface elevation and an additional location will be included to determine the peak velocity magnitude in the vicinity of the cofferdam. The locations included in the water surface elevation analysis are east and west of the GIWW structures, north and south of the Seabrook Structure, and at the location where the GIWW and IHNC meet. These locations can be referenced in Figures 4-25 and 4-26. The location of the velocity analysis for the base and half cofferdam configurations are shown in Figure A2. The blue location is the location of maximum velocity for the Base, Plan 1, Plan 2, and February 2010 conditions and the red location is that for the half cofferdam condition. The March 2010 condition includes a cofferdam across the full width of the IHNC at Seabrook so no data will be shown at Seabrook for this condition.

Average Velocity Analysis

The average velocity for flood and ebb are determined at each location and time period for all simulation conditions as are the maximum velocities for all conditions. Again, positive values are defined as those directed predominantly toward the north or east and negative values are defined as those directed predominantly toward the south or west, except at the Chef Menteur and Rigolets where positive flow is into Lake Pontchartrain and negative flow is toward the GIWW or Lake Borgne. The results of this analysis are given in Figures A3 through A10. A direction arrow is included for each location to help define the flow direction.

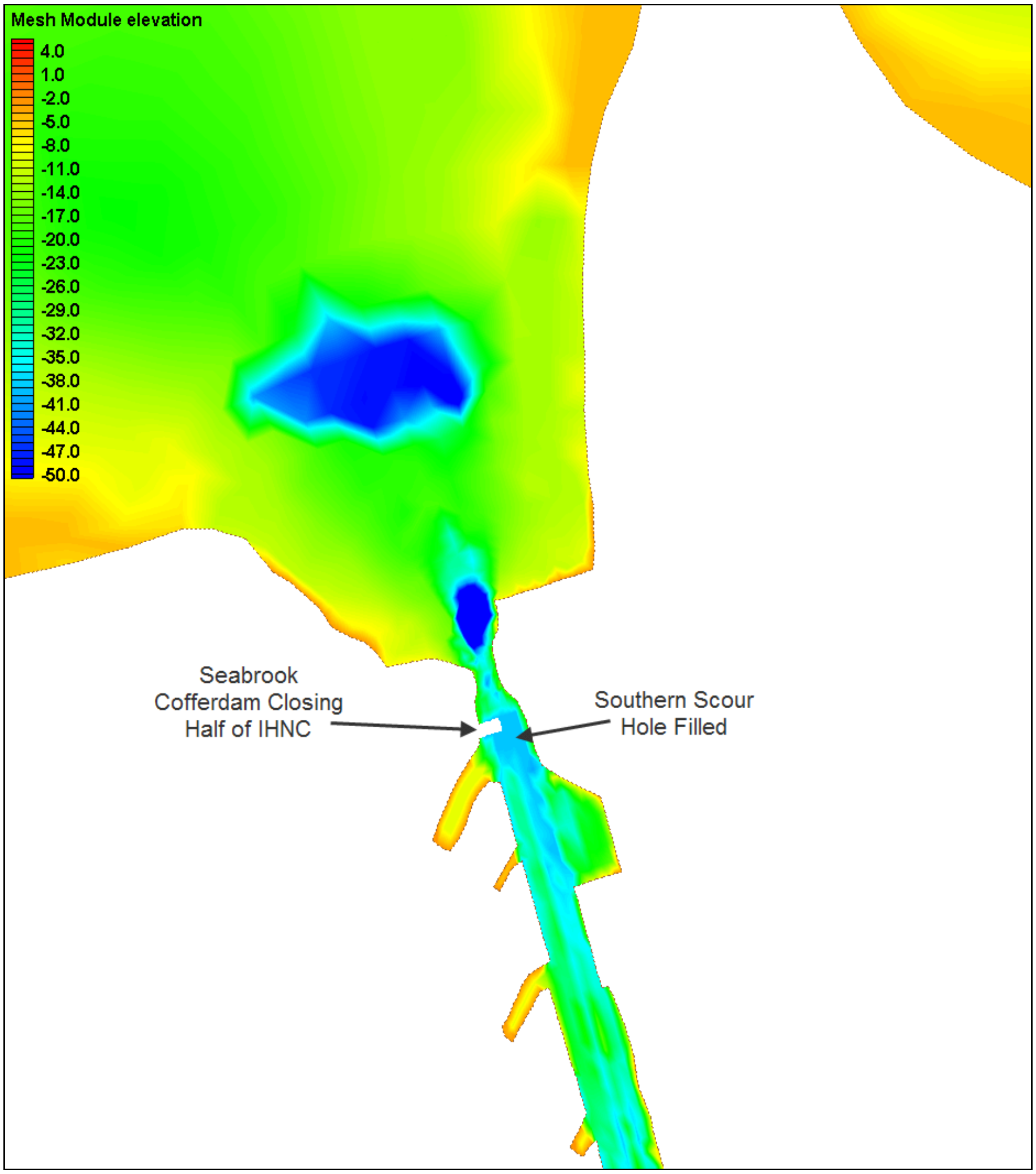


Figure A1. Seabrook Half cofferdam configuration.

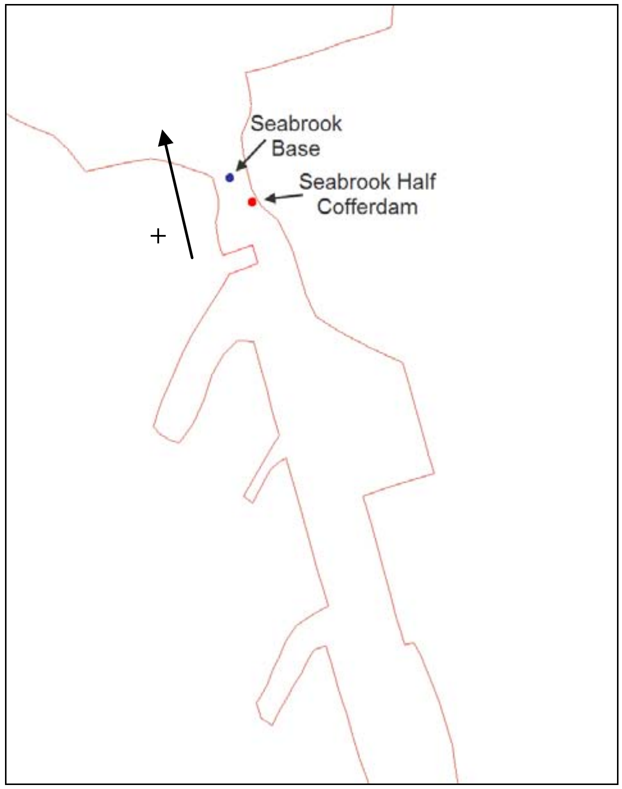
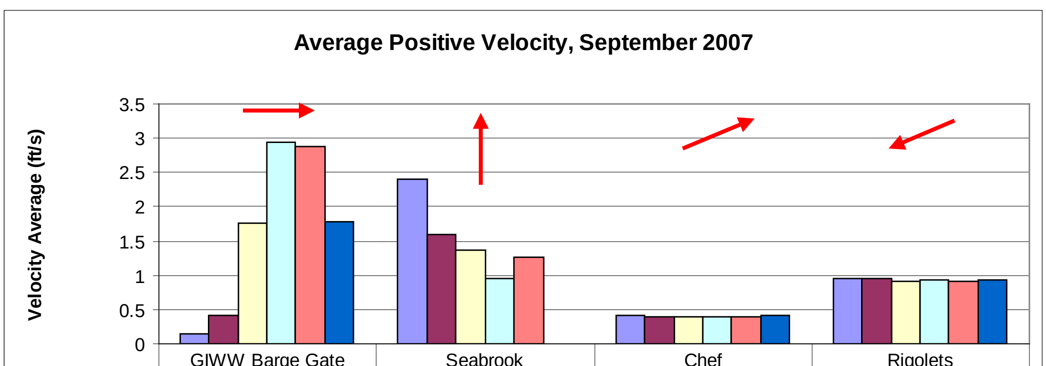
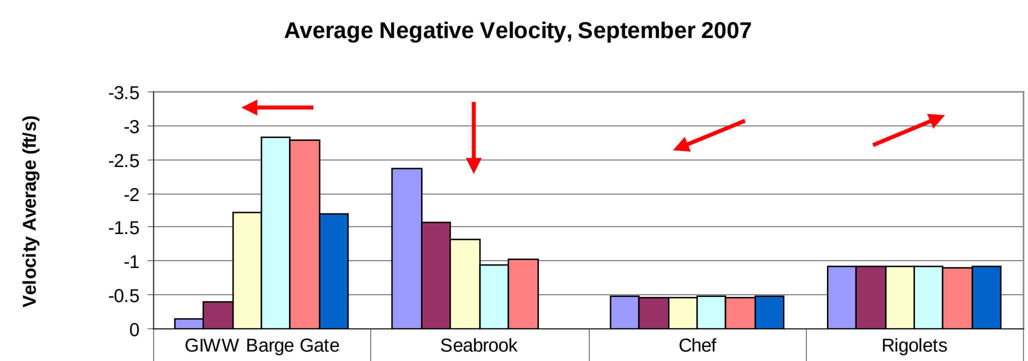


Figure A2. Hydrodynamic analysis location – Seabrook.



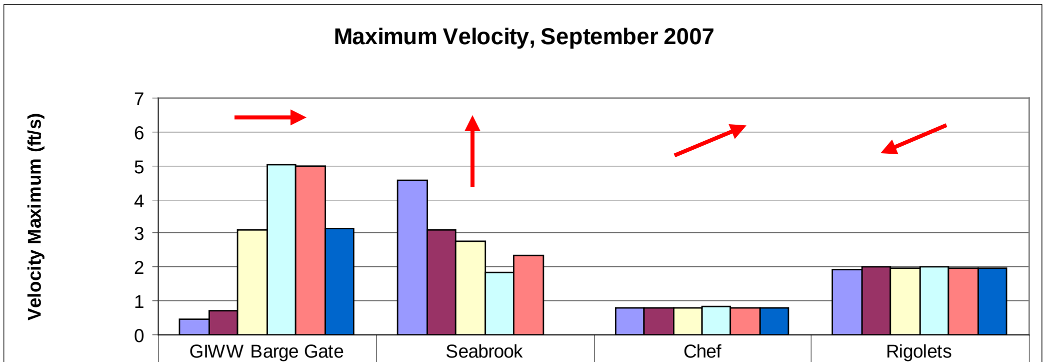
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.15	2.41	0.41	0.95
Plan 1	0.41	1.59	0.40	0.95
Plan 2	1.75	1.37	0.39	0.92
Feb 2010	2.93	0.94	0.40	0.93
SB-half	2.89	1.25	0.39	0.92
Mar 2010	1.78	0.00	0.40	0.92

Figure A3. Velocity average for September (positive).



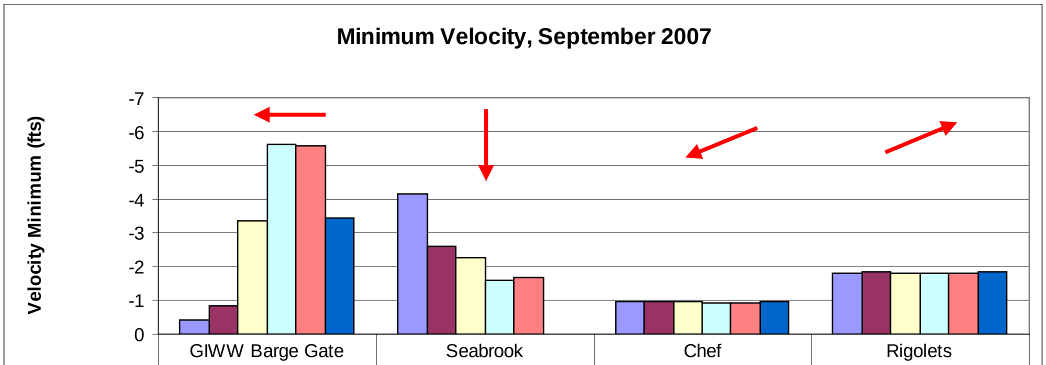
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.15	-2.36	-0.49	-0.92
Plan 1	-0.41	-1.57	-0.47	-0.93
Plan 2	-1.72	-1.32	-0.47	-0.92
Feb 2010	-2.83	-0.94	-0.47	-0.92
SB-half	-2.78	-1.02	-0.47	-0.91
Mar 2010	-1.69	0.00	-0.48	-0.92

Figure A4. Velocity average for September (negative).



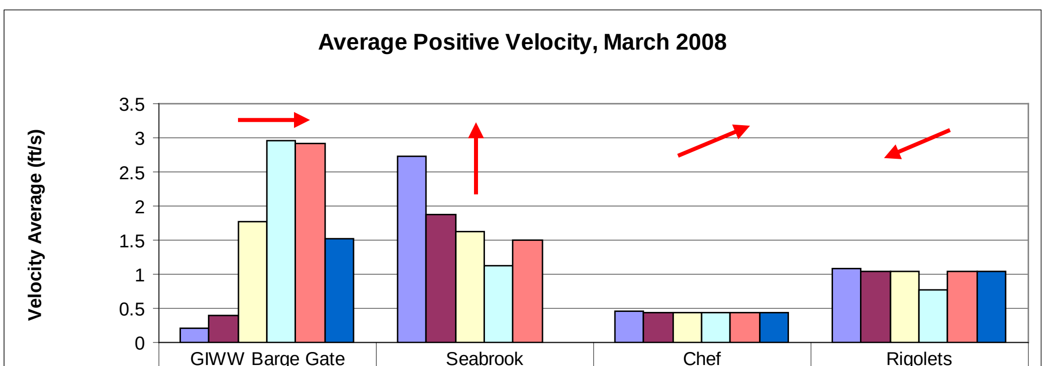
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.47	4.58	0.81	1.94
Plan 1	0.73	3.12	0.80	2.00
Plan 2	3.08	2.77	0.80	1.97
Feb 2010	5.03	1.83	0.82	2.00
SB-half	4.98	2.37	0.81	1.95
Mar 2010	3.14	0.00	0.82	1.98

Figure A5. Velocity maximum for September (positive).



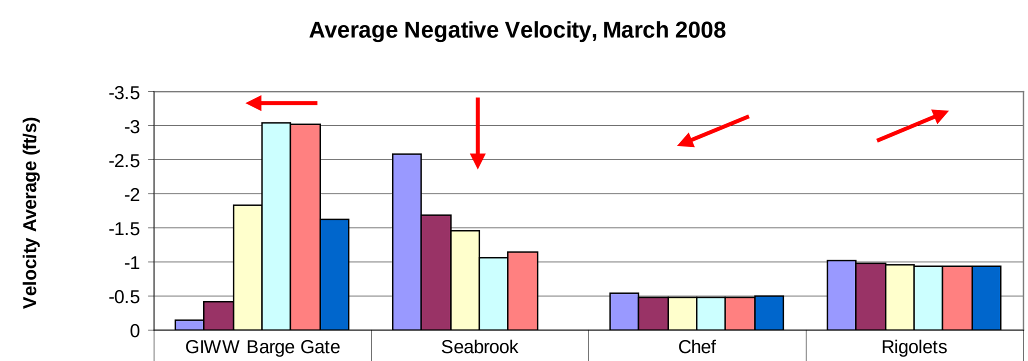
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.41	-4.13	-0.97	-1.80
Plan 1	-0.84	-2.58	-0.98	-1.85
Plan 2	-3.34	-2.28	-0.95	-1.80
Feb 2010	-5.60	-1.60	-0.94	-1.79
SB-half	-5.57	-1.69	-0.94	-1.80
Mar 2010	-3.45	0.00	-0.96	-1.84

Figure A6. Velocity minimum for September (negative).



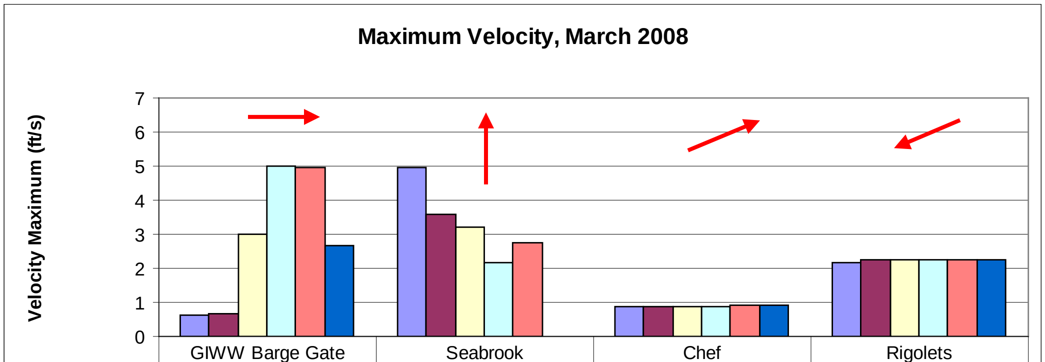
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.21	2.73	0.45	1.08
Plan 1	0.39	1.87	0.43	1.05
Plan 2	1.76	1.62	0.43	1.05
Feb 2010	2.95	1.12	0.43	0.77
SB-half	2.91	1.49	0.43	1.05
Mar 2010	1.52	0.00	0.44	1.05

Figure A7. Velocity average for March (positive).



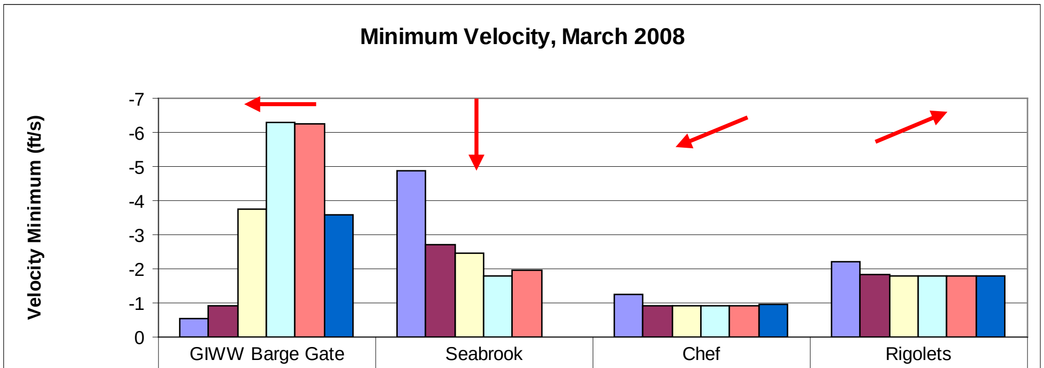
	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.14	-2.59	-0.54	-1.02
Plan 1	-0.42	-1.68	-0.48	-0.97
Plan 2	-1.83	-1.46	-0.48	-0.96
Feb 2010	-3.05	-1.05	-0.48	-0.95
SB-half	-3.03	-1.14	-0.48	-0.95
Mar 2010	-1.62	0.00	-0.50	-0.95

Figure A8. Velocity average for March (negative).



	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	0.64	4.98	0.86	2.17
Plan 1	0.67	3.57	0.88	2.24
Plan 2	3.02	3.23	0.87	2.24
Feb 2010	5.00	2.15	0.89	2.24
SB-half	4.97	2.76	0.90	2.23
Mar 2010	2.68	0.00	0.91	2.25

Figure A9. Velocity maximum for March (positive).



	GIWW Barge Gate	Seabrook	Chef	Rigolets
Base	-0.54	-4.89	-1.24	-2.21
Plan 1	-0.91	-2.69	-0.92	-1.82
Plan 2	-3.73	-2.45	-0.92	-1.81
Feb 2010	-6.30	-1.79	-0.92	-1.78
SB-half	-6.23	-1.96	-0.92	-1.78
Mar 2010	-3.58	0.00	-0.96	-1.80

Figure A10. Velocity minimum for March (negative).

A velocity summary is given for the Seabrook and GIWW locations in Table A1. The velocities at Seabrook for the half cofferdam condition are slightly higher than for the February 2010 condition in which the Seabrook area is completely open. However, the velocities in both cases are lower than the Base condition which includes no changes to the system. This trend is observed for both analysis periods. At the GIWW barge gate the velocity average and extremes are very similar for the February 2010 and half cofferdam condition, indicating that the cofferdam does not influence the flows at the GIWW structures. At the Chef Menteur and Rigolets, the effects of the cofferdam, full or half, are negligible.

Table A1. Average velocity values at the GIWW and Seabrook structures for the base and each construction sequence plan and the half Seabrook cofferdam during both analysis periods

Average Velocity (ft/s)	Base				Feb 2010				Seabrook Half Cofferdam				Mar 2010			
	Positive		Negative		Positive		Negative		Positive		Negative		Positive		Negative	
	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar
GIWW	0.2	0.2	-0.2	-0.1	2.9	3.0	-2.8	-3.1	2.9	2.9	-2.8	-3.0	1.8	1.5	-1.7	-1.6
Seabrook	2.4	2.7	-2.4	-2.6	0.9	1.1	-0.9	-1.1	1.3	1.5	-1.0	-1.1	0.0	0.0	0.0	0.0

Percent Less Than Analysis

The percent less than analysis is performed on both simulation periods for the GIWW barge gate, Seabrook, Chef Menteur, and Rigolets locations – the same locations shown in the previous velocity analysis. These plots show velocity magnitude on the x-axis and percentage of time on the y-axis. At the maximum velocity magnitude, the percentage is almost 100 since the velocity is equal to or less than this value over the length of the simulation. All lines cross zero at 0% since the velocity magnitude is always greater than zero. Where each line crosses 50% the velocity magnitude is greater half the time and less half the time over the four week analysis period. The same trends are seen in this analysis as in the previous velocity analysis. The velocity magnitude is slightly higher for the half cofferdam location at Seabrook (Figures A12 and A16) when compared to the no cofferdam (February 2010) condition. However, the half cofferdam has lower velocities at Seabrook than the Base, Plan 1, and Plan 2 conditions. At the GIWW barge gate (Figures A11 and A15) the velocities are highest for the half cofferdam and February 2010 condition, but the two are very similar throughout the range of velocity magnitudes.

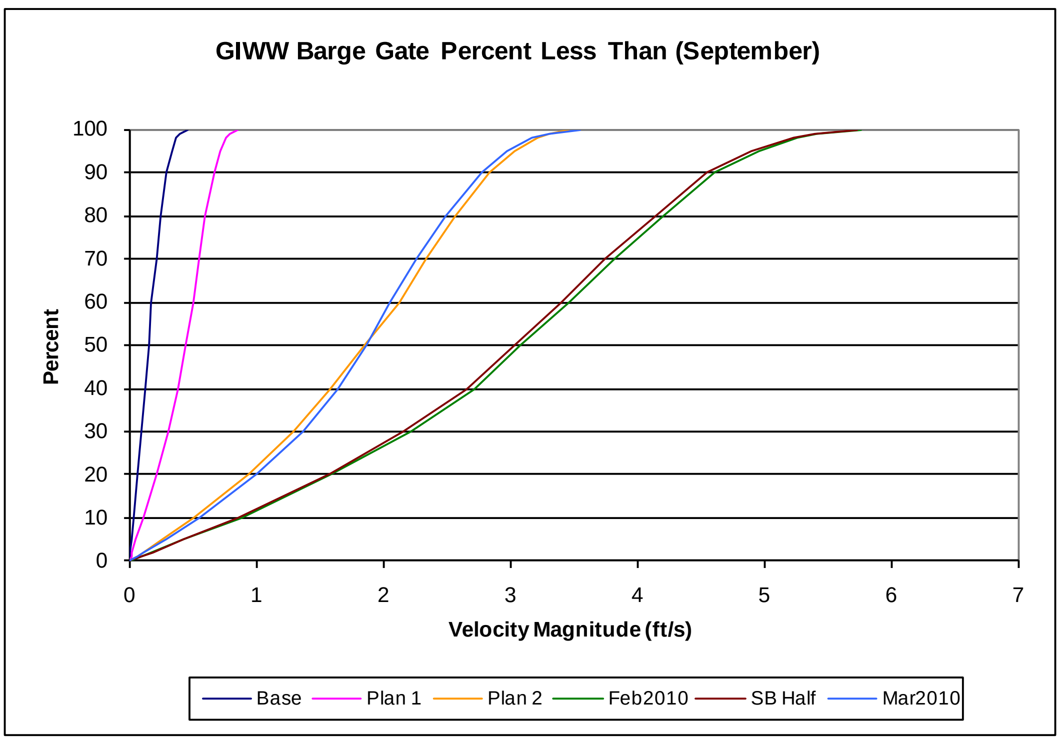


Figure A11. GIWW Barge Gate percent less than plot for September.

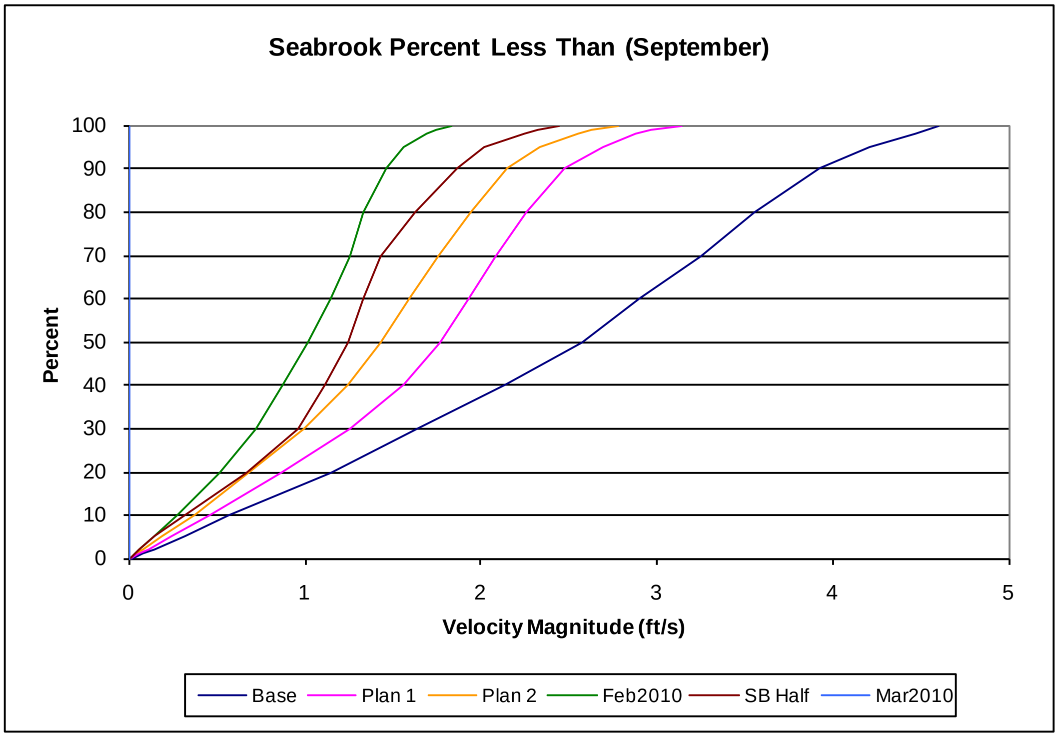


Figure A12. Seabrook percent less than plot for September.

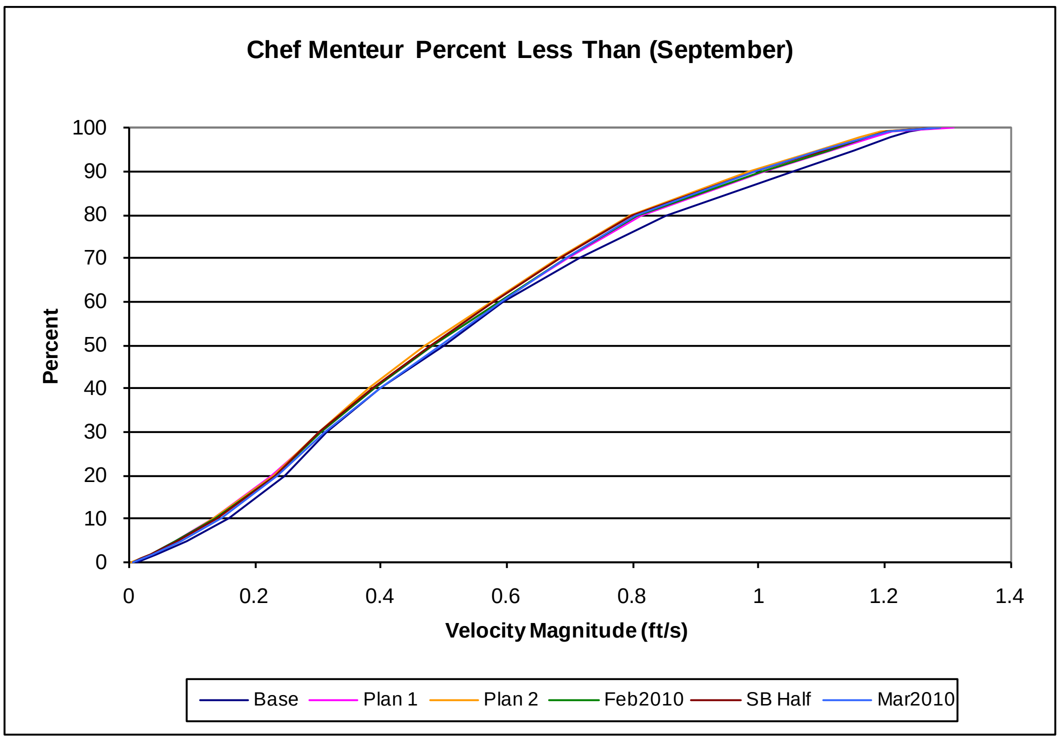


Figure A13. Chef Menteur percent less than plot for September.

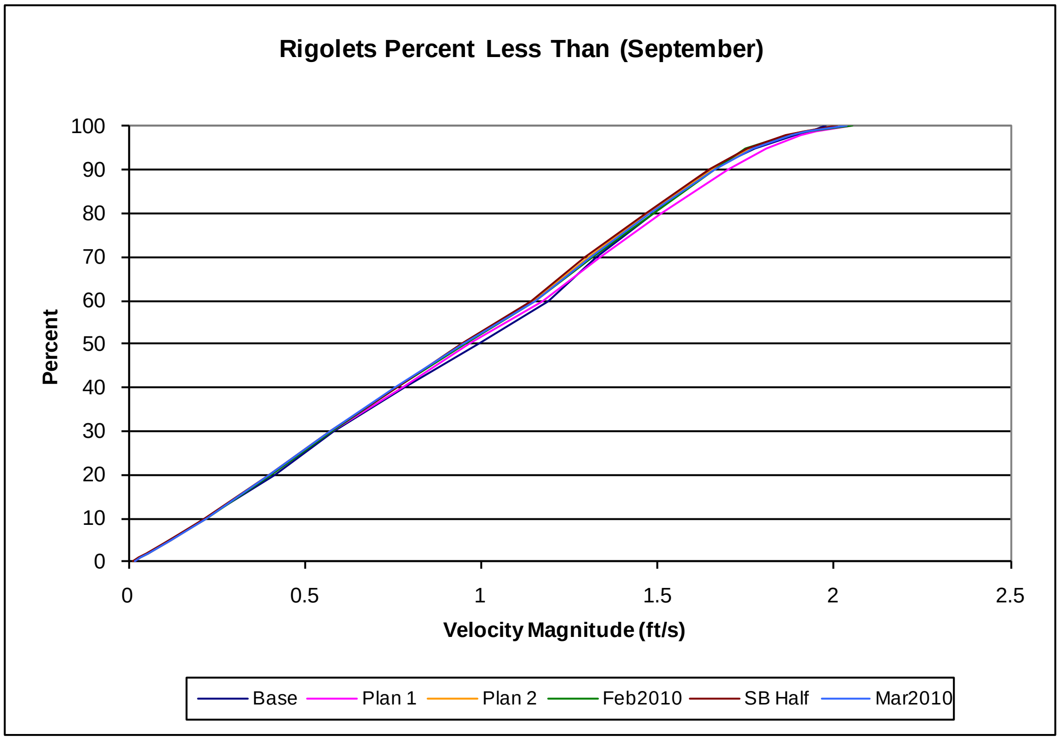


Figure A14. Rigolets percent less than plot for September.

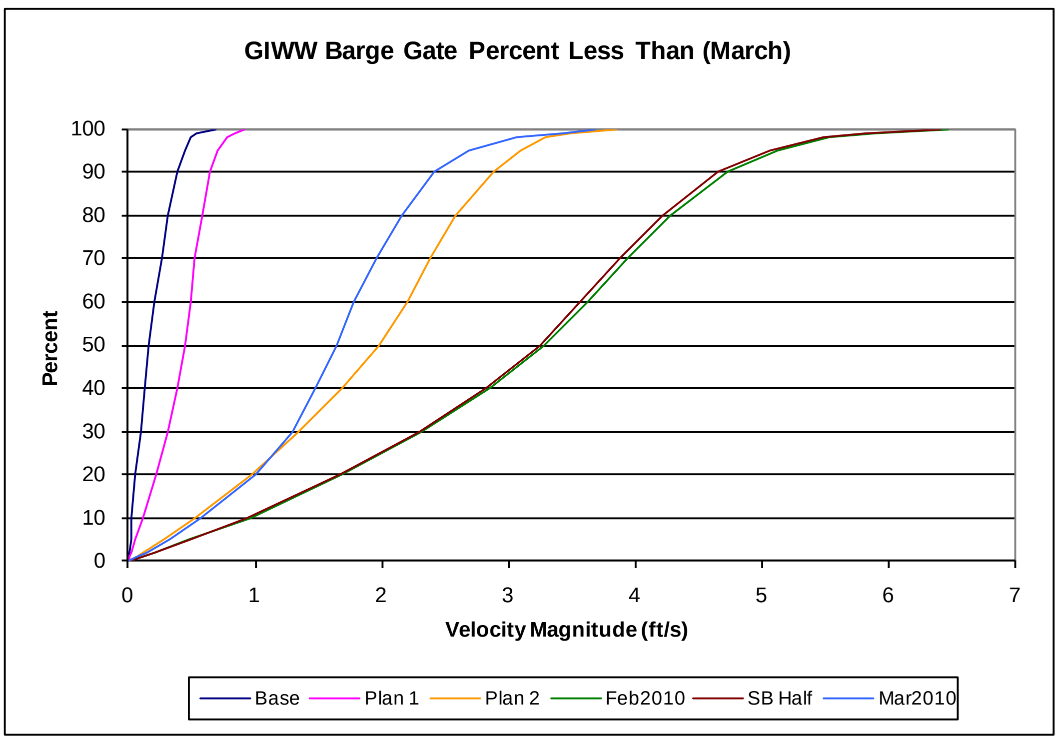


Figure A15. GIWW Barge Gate percent less than plot for March.

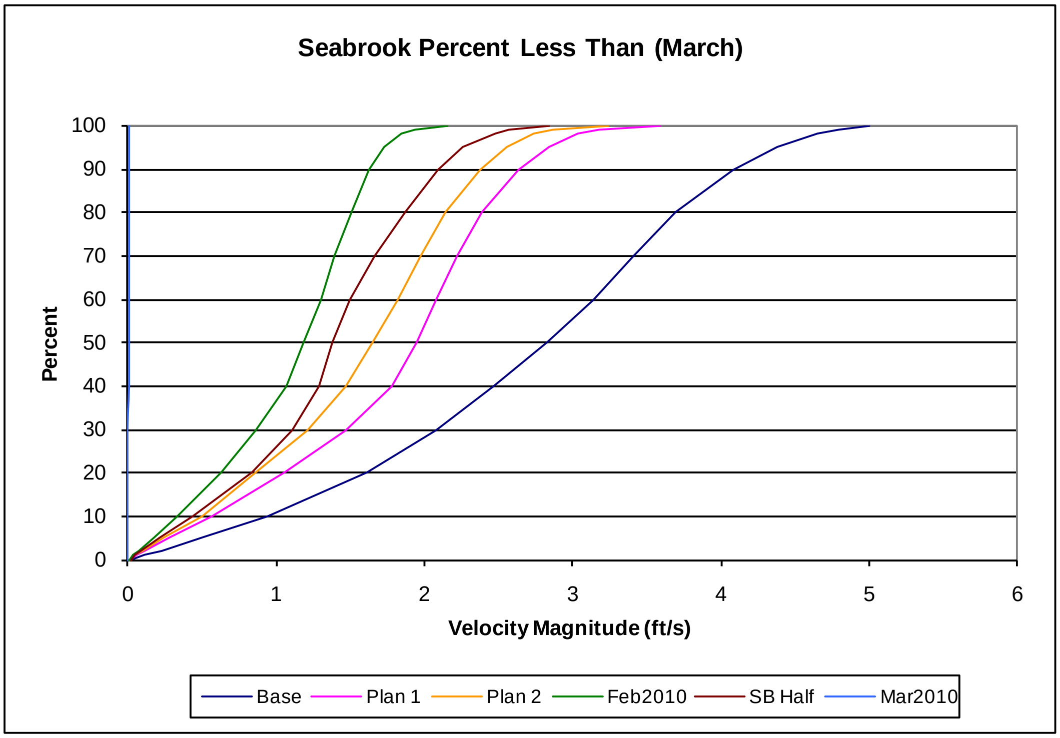


Figure A16. Seabrook percent less than plot for March.

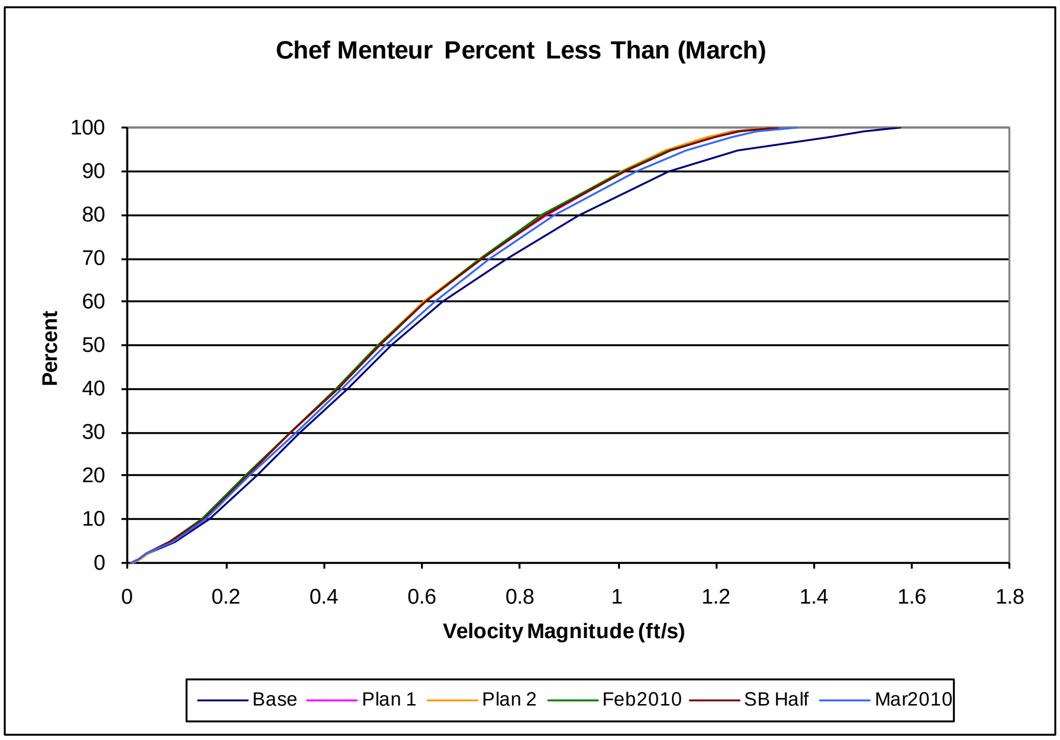


Figure A17. Chef Menteur percent less than plot for March.

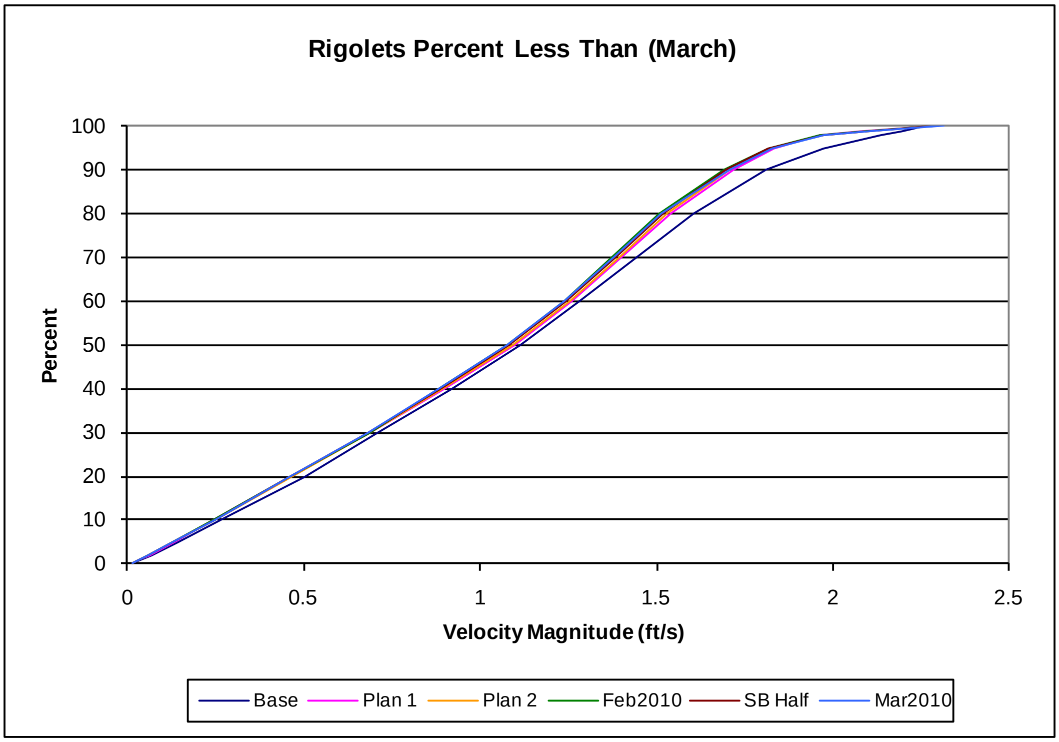


Figure A18. Rigolets percent less than plot for March.

Water Surface Elevation Analysis

The water surface elevation analysis is performed for this additional plan at 5 locations – 250 ft east and west of the GIWW structures, 250 ft north and south of the Seabrook structure, and in the GIWW where it meets the IHNC. The water surface elevation for each location and alternative is shown in Figures A19 to A28. These figures display 12.5 days of each simulation period (August 22 – September 3, 2007; March 9 - 21, 2008).

The results of the water surface elevation analysis show that the half cofferdam condition at Seabrook does affect the flow through this pathway. The tidal range is increased on average at the southern Seabrook location when a complete structure is in place, as in the March 2010 configuration (Figures A22 and A27). The water surface elevation range is lower for the half cofferdam than for the full cofferdam, as would be expected due to the half cofferdam allowing flow to pass through this location. The half cofferdam condition actually produces tidal ranges that are lower than the Base condition, likely due to the other structures in place for this simulation. At the northern Seabrook location (Figures A21 and A26), there is a small elevation range due to the larger cross sectional area as the IHNC enters Lake Pontchartrain. The half cofferdam does

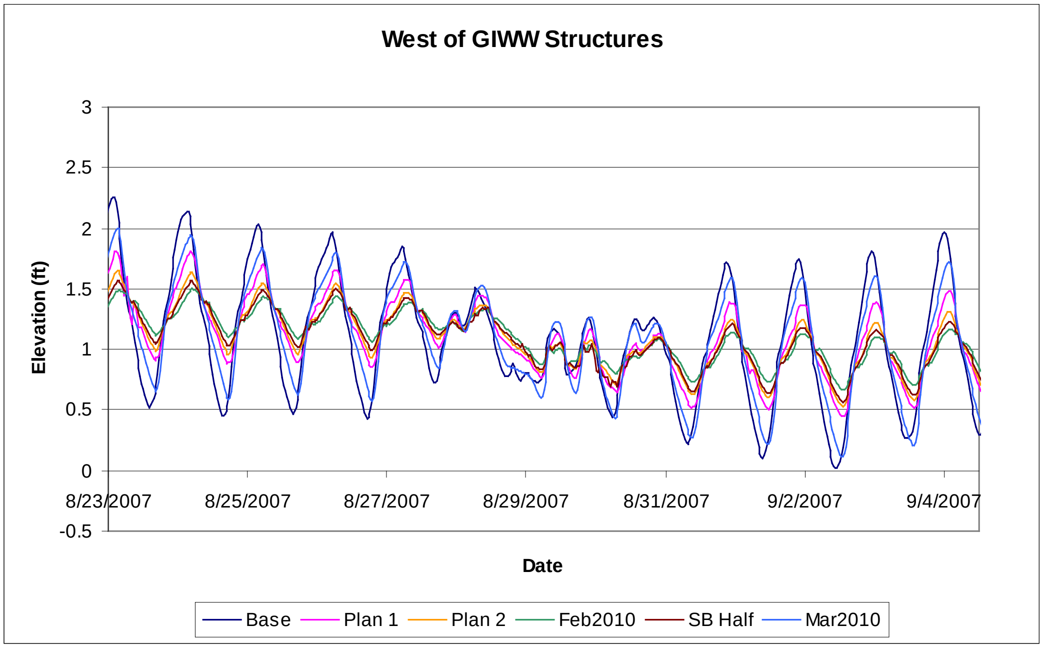


Figure A19. Water surface elevation west of GIWW structures (September).

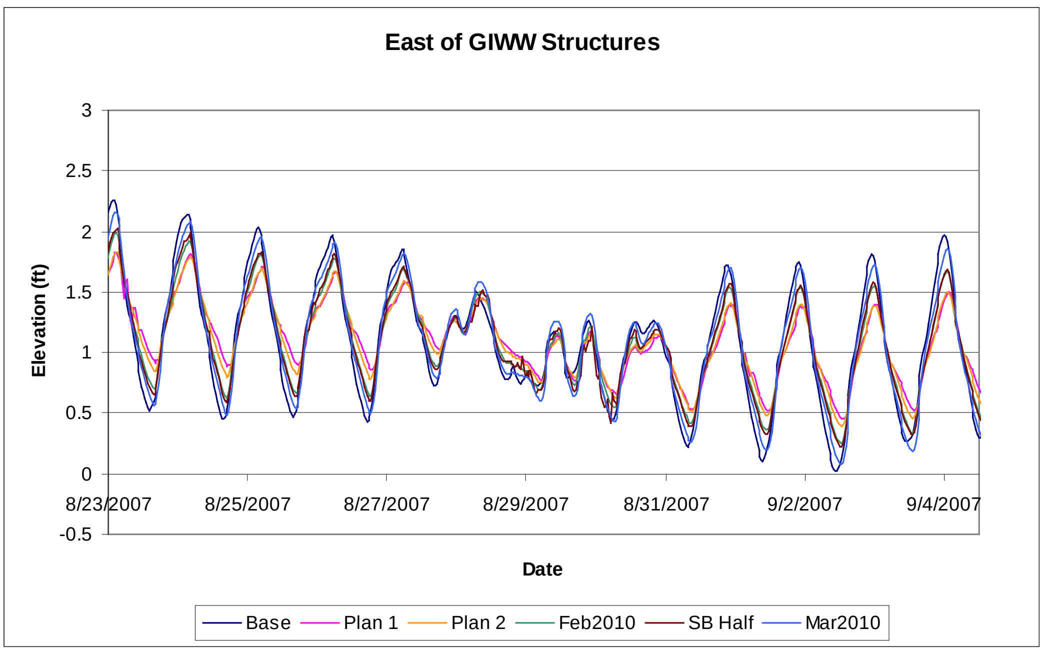


Figure A20. Water surface elevation east of GIWW structures (September).

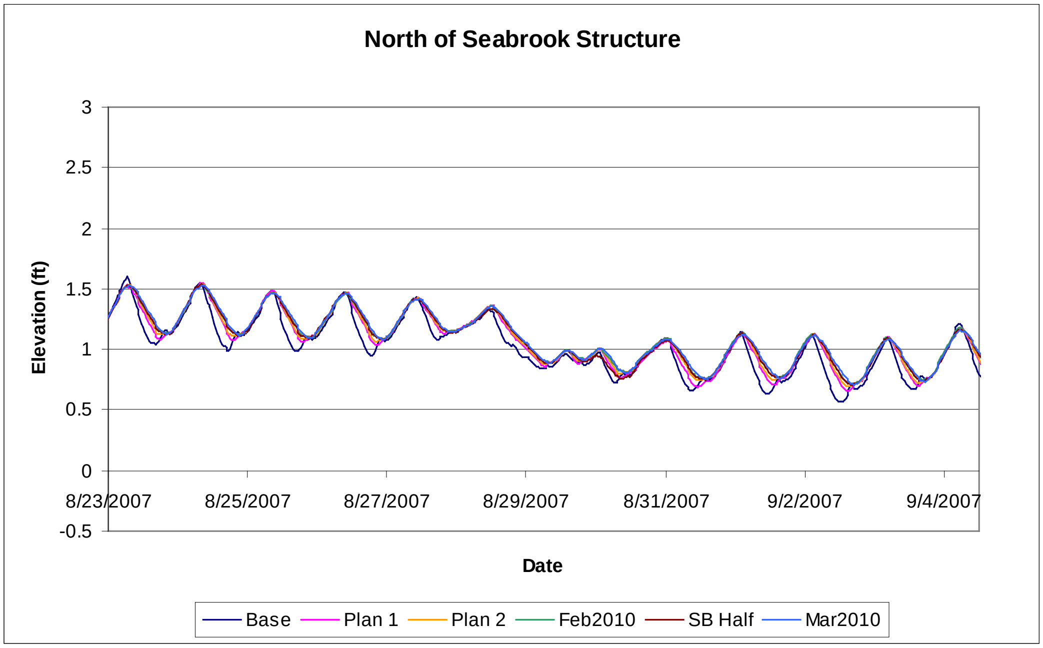


Figure A21. Water surface elevation north of Seabrook structure (September).

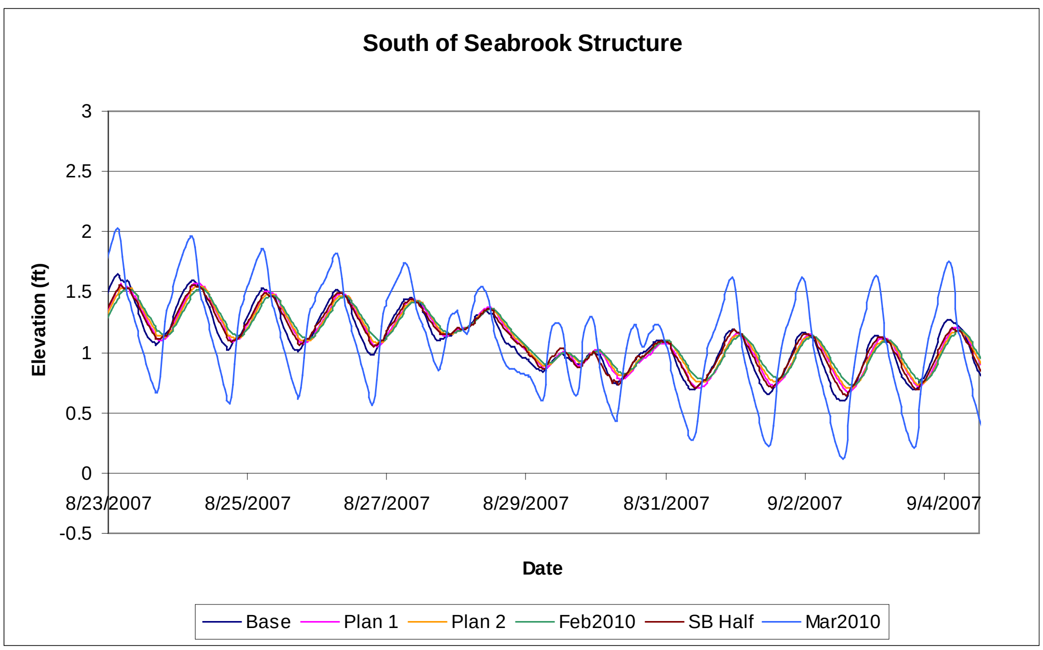


Figure A22. Water surface elevation south of Seabrook structure (September).

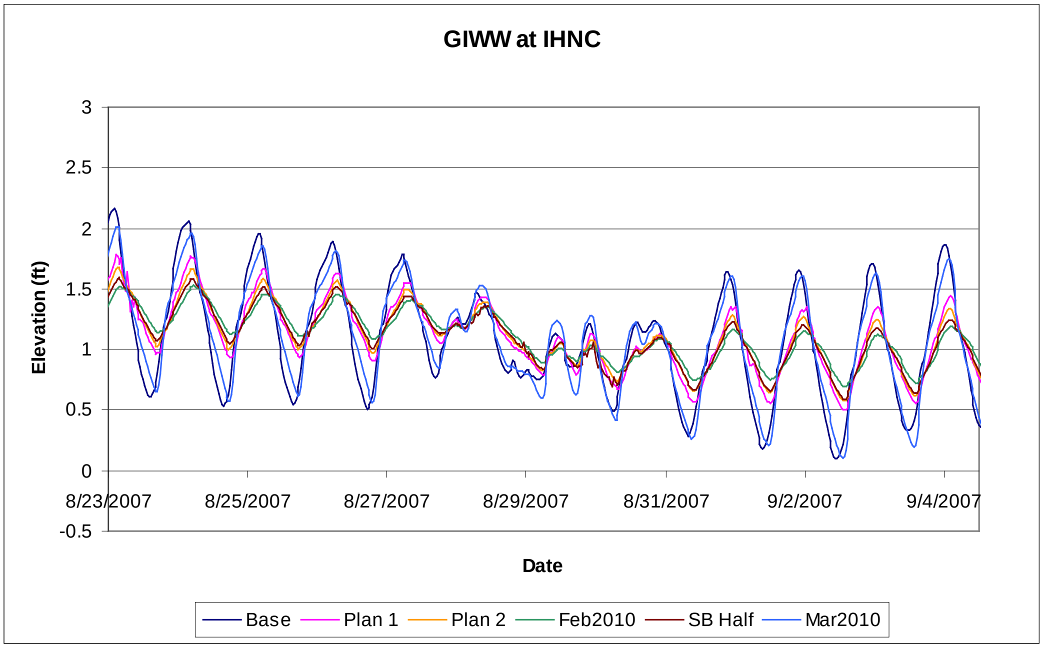


Figure A23. Water surface elevation in GIWW at IHNC (September).

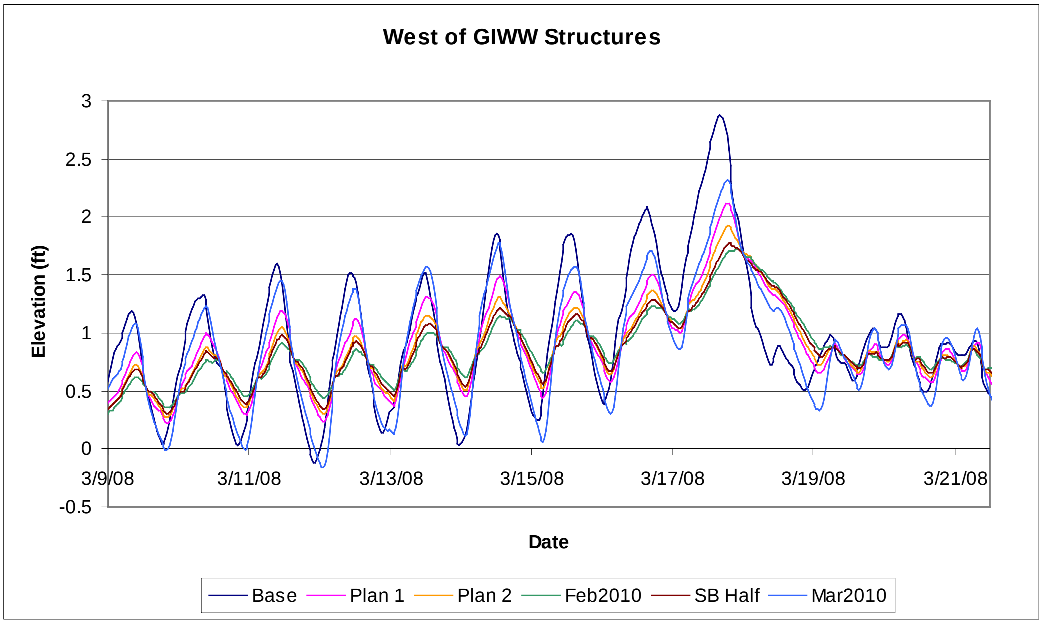


Figure A24. Water surface elevation west of GIWW structures (March).

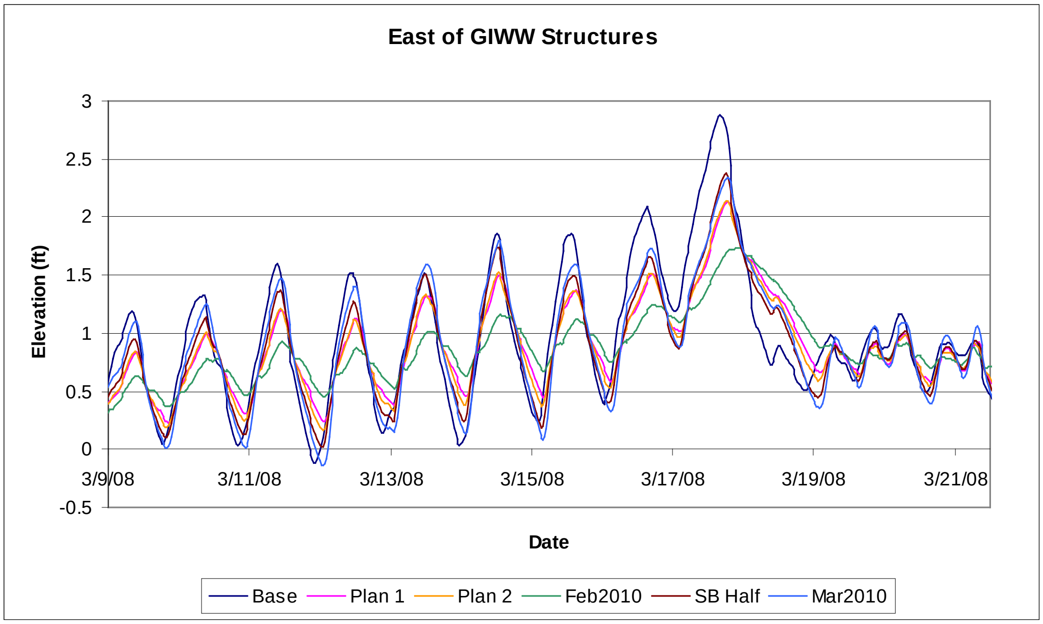


Figure A25. Water surface elevation east of GIWW structures (March).

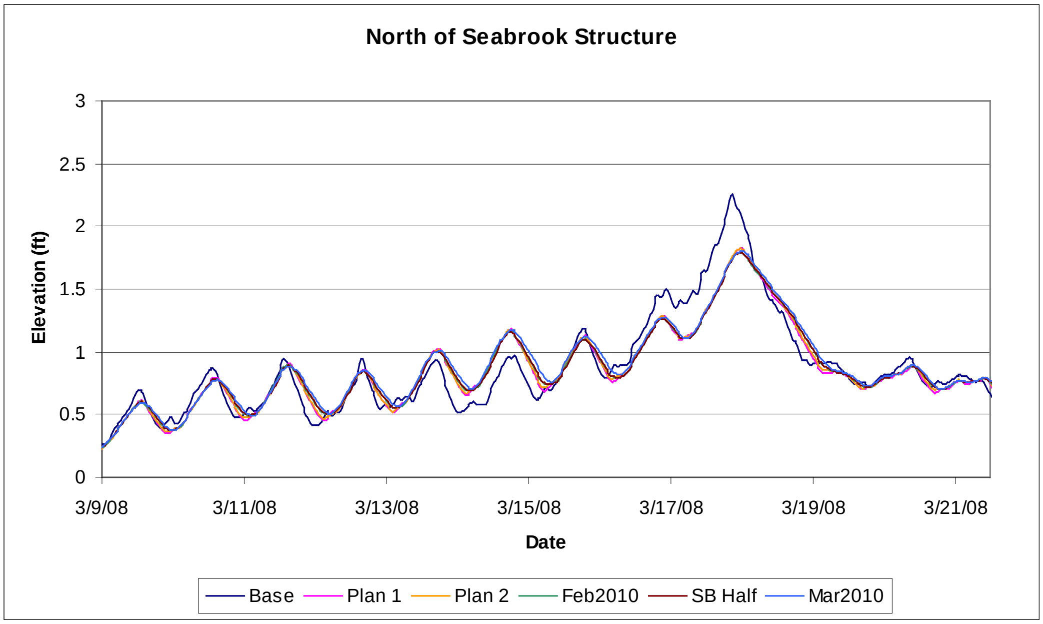


Figure A26. Water surface elevation north of Seabrook structure (March).

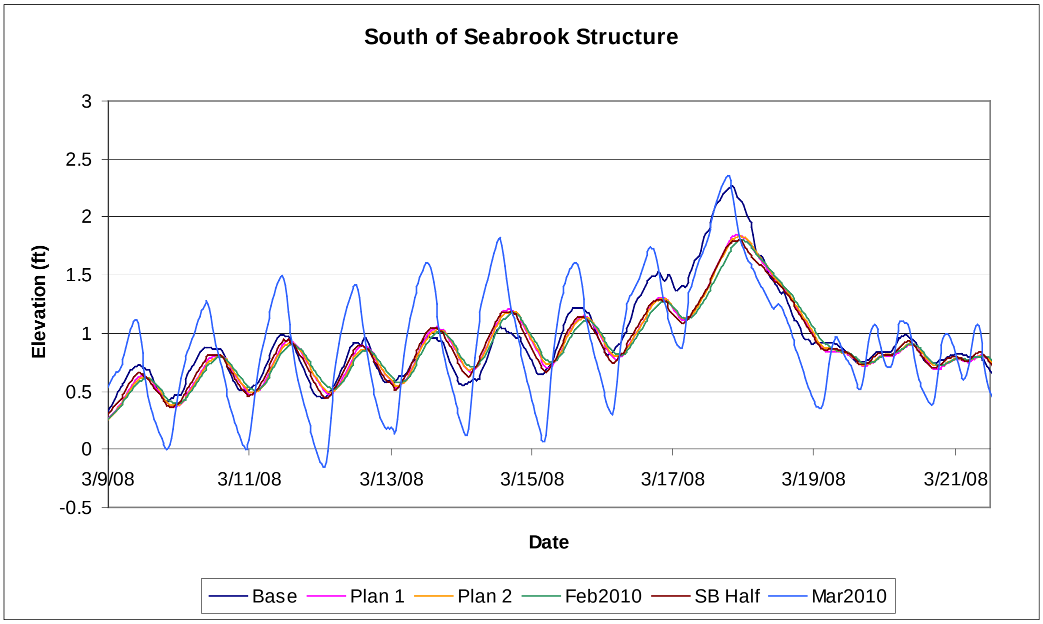


Figure A27. Water surface elevation south of MRGO Seabrook structure (March).

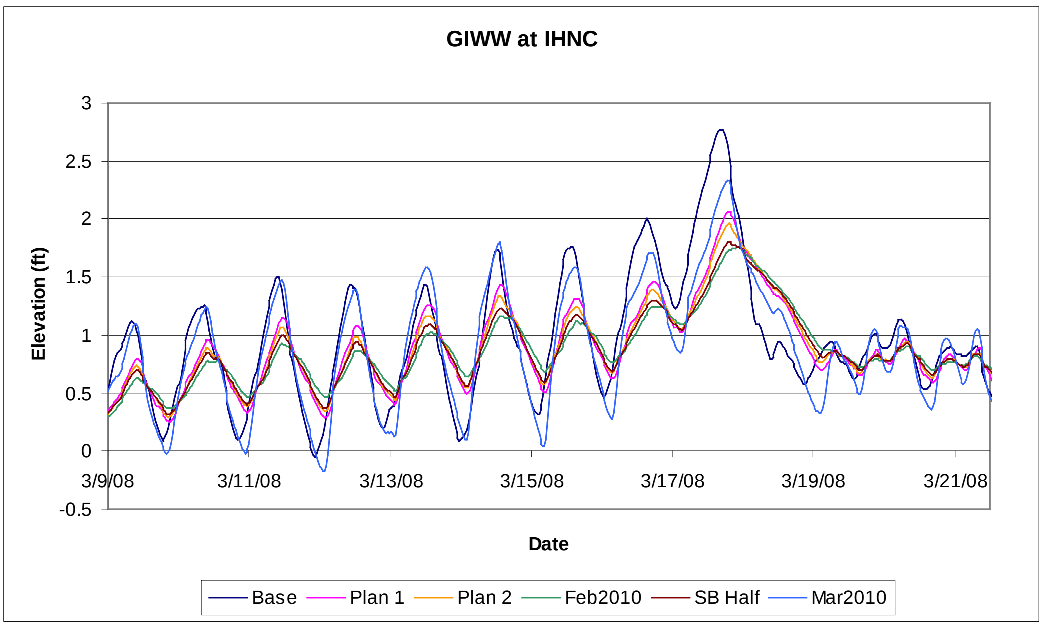


Figure A28. Water surface elevation in GIWW at IHNC (March).

affect the elevation here, though, such that the tidal range for the half cofferdam is slightly lower than the completely open waterway in the February 2010 condition. Where the GIWW meets the IHNC, the water surface elevations are very similar to those when no cofferdam is in place at Seabrook (Figures A23 and A28). This same trend continues to the western side of the GIWW structures (Figures A19 and A24). The elevation range is small like that of the no Seabrook cofferdam case, yet the range is

slightly higher with the half cofferdam since it traps more water in the system (between the GIWW and Seabrook structures) due to the restricted flow pathways. On the East side of the GIWW structures (Figures A20 and A25), however, the water surface elevation range is increased from the no cofferdam condition due to increased flow resistance into the system. The half cofferdam condition produces a lower elevation range than does the full cofferdam at Seabrook for the same reasons that the other responses are observed. The structures at the GIWW sector gate location and the Seabrook gate location prevent the ease of movement of the water into this area, causing piling of water at various locations. When these structures are in place yet flow is still able to pass, the water surface elevation range is lower than the base condition which provided a larger cross sectional area for flow and generally a larger range in the elevation. The March 2010 condition, however, completely blocks the flow through Seabrook which generates an increase in the tidal range on average in the system due to the allowance of flow through the GIWW although there is no outlet at the upstream end.

Conclusion

The velocity magnitudes for the half cofferdam configuration do not yield values larger than those experienced in the Base condition. This plan does increase the velocities at the GIWW barge gate but no more than when there is no cofferdam at Seabrook. The water surface elevations do vary slightly with this plan but they, too, are very similar to the elevations observed when no cofferdam is in place at Seabrook. The effect on the elevation range is much less for the half cofferdam condition than for the full cofferdam condition at Seabrook. From these results, the half cofferdam at Seabrook appears to be a worthwhile consideration due to its effects on the velocity magnitudes and water surface elevations within the system. However, the uneven bathymetry in the confined area at Seabrook may produce vertical velocity patterns that are too extreme for navigation. If this plan is a serious consideration, a three dimensional velocity analysis should be performed to assess its safety for navigation.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
December 2010

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Seabrook and Borgne Alignment Construction Sequence Hydrodynamic Study

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Jennifer N. Tate and Cassandra G. Ross

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/CHL TR-10-11

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
New Orleans District, Hurricane Protection Office
7400 Leake Ave., Rm 184
New Orleans, LA 70118

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U.S. Army Corps of Engineers (USACE) Hurricane Protection Office (HPO) is authorized to provide New Orleans, Louisiana, with a risk reduction system for the one percent exceedance flood (HSDRRS). The purpose and need for the proposed action is to provide, in a timely manner, the 100-year level of risk reduction from flood damage to the areas surrounding the IHNC due to flooding from hurricanes and other severe storm events. This risk reduction is being accomplished through the construction of a comprehensive system of levees, gates, and drainage structures. Several planned structures (to be located along the levee system) allow for continued navigation in the Inner Harbor Navigational Canal (IHNC), Bayou Bienvenue, and the Gulf Intracoastal Waterway (GIWW). The IHNC Seabrook, Bayou Bienvenue, and GIWW gate structures are designed to remain open during normal tidal conditions with the ability to close during surge events. Numerical model studies were performed by the USACE Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) to assess the impacts of these navigation structures on hydrodynamics and larval transport. HPO requested that ERDC also perform a numerical modeling study for the purpose of analyzing the temporary construction impacts of proposed HSDRRS measures to be placed in the GIWW and the Mississippi River Gulf Outlet (MRGO). The work presented in this report documents hydrodynamic modeling and analysis of two construction sequence plans which will occur during the construction of the

15. SUBJECT TERMS
Adaptive hydraulics (AdH)
Hydrodynamic modeling
Inner Harbor Navigation Canal
Larval Fish Transport Modeling
New Orleans Hurricane Protection
Particle Tracking Model (PTM)
Seabrook

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED	80	

14. ABSTRACT (concluded)
Borgne alignment and Seabrook structures included in the HSDRRS. This report specifically focuses on the construction sequence plans during which the Bayou Bienvenue structure and GIWW sector gate are being built as well as the construction of the Seabrook structure. The February 2010 plan includes cofferdams on the Bayou Bienvenue and at the GIWW sector gate in addition to closing the MRGO at La Loutre and south of Bayou Bienvenue. The March 2010 plan adds a cofferdam at Seabrook. Water surface elevation, velocity magnitude and direction, and percent less than analyses were performed at several locations within the model domain, focusing on the areas likely to be affected by the plan changes.